Attachment 2

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD

Request for a Clean Air Act Section 209(b) Waiver of Preemption for California's Adopted and Amended New Motor Vehicle Regulations and Incorporated Test Procedures to Control Greenhouse Gas Emissions:

SUPPORT DOCUMENT

December 21, 2005

I. Introduction

At its September 23-24, 2004 hearing, the California Air Resources Board (CARB or Board) approved the adoption and amendment of regulations affecting passenger cars, light-duty trucks, and medium-duty passenger vehicles that California currently regulates under its second generation Low-Emission Vehicle (LEV II) program.[1] The regulations affect vehicles that will be certified for sale in California beginning with the 2009 model year. Like other parts of the LEV II program, the regulations require declining fleet average emissions – in this case of certain greenhouse gases – from new motor vehicles sold in California.

The Board approved the proposed amendments, with modifications, to California's passenger vehicle emissions standards and related test procedures in Resolution 04-28 on September 24, 2004. See Attachment 3, item 7. That Resolution directed staff to make minor modifications to the regulatory text, and to seek further public comment on those modifications. Staff did so (see Attachment 3, items 9 and 10), and forwarded the regulations to the Legislature (Attachment 3, item 11) as required by the authorizing legislation (Attachment 3, item 1). As also directed by the Board, the Executive Officer completed the remaining steps in the rulemaking process, including completing an environmental review and forwarding the adopted regulations and other regulatory documents to California's Office of Administrative Law (OAL). See Attachment 3, items 12, 13 and 14. OAL approved the regulatory action on September 15, 2005. See Attachment 3, item 15. The regulations have a January 1, 2006 effective date. Title 13, California Code of Regulations (13 CCR), section 1961.1(g).

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[1] EPA has granted California a waiver of preemption for its LEV II standards and test procedures, as amended. 68 Fed.Reg. 19811 (April 22, 2003). See also note 3.

The subject regulatory action to control greenhouse gases from motor vehicles (hereinafter "Greenhouse Gas Rulemaking," "Rulemaking," "Greenhouse Gas Regulations," or "Greenhouse Gas Emission Standards") includes amendments to 13 CCR, sections 1900 and 1961, and the adoption of a new section 1961.1. The specific regulatory text and amendments to the incorporated "California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" covered by the Greenhouse Gas Rulemaking are shown in underline/~~strikethrough~~ format in Attachment 3, item 16. For convenience, the "clean" text of both the regulations and the incorporated test procedures are included as Attachment 3, item 17.

In simple terms, the Greenhouse Gas Rulemaking added four greenhouse gas air contaminants[2] to the vehicular criteria and criteria-precursor pollutants, and toxic air contaminants, that California was already regulating. The Rulemaking established a declining fleet average emission standard for these gases, with separate standards for the lighter and heavier portions of the passenger vehicle fleet. The Greenhouse Gas Regulations provide delayed compliance for small, independent low volume, and intermediate size manufacturers. The Regulations also provide alternative compliance methods including credit generation from alternative fuel vehicles, and averaging, banking, and trading of credits within and among manufacturers. Those credits – and debits from exceeding the maximum level in a given model year – must be equalized within five years of their generation, with the first equalization required in 2014. To ensure compliance with the adopted standards, the Rulemaking also requires additional certification emissions testing for the covered greenhouse gases.

Section II. of this document provides a brief overview of California's new motor vehicle certification program for passenger vehicles. Section III. provides an overview of the regulations adopted and amended, and test procedures amended, by the Greenhouse Gas Rulemaking. Section IV. describes the criteria governing U.S. EPA's evaluation of California's waiver requests. Section V. demonstrates how U.S. EPA must apply those criteria here to grant California's request.

II. THE PREEXISTING CALIFORNIA PASSENGER VEHICLE REGULATIONS

Continuing California's long tradition of setting ambitious but attainable emission reduction goals, CARB adopted Low-Emission Vehicle (LEV I) standards in a 1990-1991 rulemaking. The LEV I standards ran from 1994 through 2003. In 1998 the Board amended the LEV regulations to add what are now known as the LEV II standards, which run from 2004 and reach their most stringent levels for the 2010 and

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[2] Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs). "Air contaminant" or "air pollutant" is defined at Cal. Health & Saf. Code section 39013.

later model years. The LEV II regulations represent continuing progress in emission reductions, and are advancing the state's clean air goals through improved emission reduction standards for automobiles. As the state's passenger vehicle fleet continues to grow and more sport utility vehicles and pickup trucks are used as passenger vehicles rather than work vehicles, the more stringent LEV II standards are helping California meet federally-mandated clean air goals first outlined in California's 1994 State Implementation Plan (SIP).

LEV II vehicles must meet stringent maximum emission standards for ozone-forming non-methane organic gas (NMOG) and oxides of nitrogen (NOx), carbon monoxide (CO), particulates, and the air toxic formaldehyde, and a maximum highway NOx standard that is measured using the federal Highway Fuel Economy Test (HWFET; 40 CFR 600 Subpart B). LEV II vehicles must also meet a declining fleet average NMOG standard. This fleet average NMOG standard provides manufacturers with flexibility to apply emission reduction technologies in varying degrees model-by-model, while the overall emissions from their respective fleets continue to decline substantially. Further flexibility comes from manufacturers' ability to bank NMOG credits for future use, to acquire credits from other manufacturers, and to carry forward debits for a limited time.

Passenger vehicles certifying to the LEV II standards must also meet stringent evaporative, on-board diagnostic (OBD), and other requirements to be fully certified for sale in California. A complete listing of California's passenger vehicle certification requirements is available at http://www.arb.ca.gov/msprog/onroad/cert/pc-ldt-mdv_regulationslinks_20041022.xls.

For all of the above primary elements of California's passenger vehicle program, including provisions referencing the federal Highway Fuel Economy Test, U.S. EPA has either waived federal preemption or confirmed California's determination that they fall within the scope of previous waivers.[3]

[3] See e.g. 68 Fed.Reg. 19811 (April 22, 2003). A few minor amendments specific to LEV II remain pending with U.S. EPA. 70 Fed.Reg. 22034 (April 28, 2005). See April 12, 2004 letter from Catherine E. Witherspoon to Administrator Michael O. Leavitt regarding two sets of LEV II follow-up amendments, available at U.S. EPA Docket ID OAR-2004-0057-0002. See also December 20, 2004 letter from Ms. Witherspoon to Administrator Leavitt re: Request for New Waiver for Limited Element Expanding Particulate Standard to Gasoline Vehicles, available at U.S. EPA Docket ID OAR-2004-0057-0031.

III. THE GREENHOUSE GAS REGULATIONS – OVERVIEW

A. The Need for Control

The State of California has traditionally pioneered efforts to reduce air pollution, dating back to 1963 when the California New Motor Vehicle Pollution Control Board adopted the nation's first motor vehicle emission standards. California likewise has a long history of actions undertaken in response to the threat posed by climate change; this history is described in the Staff Report for this rulemaking. See Attachment 3, item 3, pp. 27-38.

The earth's climate is changing because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases (GHGs), primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs). The heat-trapping properties of greenhouse gases are undisputed. Although there is uncertainty about exactly how and when the Earth's climate will respond to increasing concentrations of greenhouse gases, many scientific observers have indicated that detectable changes are under way. There most likely will continue to be changes in temperature and precipitation, soil moisture, and sea level, all of which could have significant adverse effects on California's ecological systems, as well as on human health and the economy.

Climate is a central factor in California life. It is at least partially responsible for the State's rapid population growth in the past 50 years, and largely responsible for the success of industries such as agriculture and tourism. The observed and future effects of climate change on California have been widely studied from a variety of perspectives. The signs of a global warming trend continue to become more evident and much of the scientific debate is now focused on expected rates at which future changes will occur.

Climate change threatens California's public health, water resources, agricultural industry, ecology, and economy. Direct health impacts due to climate change include extreme events, such as heat waves, droughts, increased fire frequency, and increased storm intensity resulting in flooding and landslides. Secondary or indirect health effects include damages to infrastructure causing, for example, sanitation and water treatment problems leading to an increase in water-borne infections. Air quality impacts such as increases in ground-level ozone due to higher temperatures will also cause secondary health impacts. Poor and immigrant populations (who often reside in urban areas where the heat island effect actually increases warming and the consequent effects of heat) are more vulnerable to climate change as they are often without adequate resources to control their personal environment with appliances such as air conditioners or to seek medical attention. Thus, these communities are often the first to experience negative climate change impacts like heat-related death and illness, respiratory illness, infectious disease, and economic and cultural displacement.

Water resources in drier climates, such as California, tend to be more sensitive to climate changes. Because evaporation is likely to increase in a warmer climate, lower river flows and lake levels will result, particularly in the summer. If stream flow and lake levels drop, groundwater also will be reduced. The seasonal pattern of runoff into California's reservoirs is susceptible to climatic warming. Winter runoff is predicted to increase, while spring and summer runoff would decrease. This shift would be problematic, because the existing reservoirs are not large enough to store the increased winter flows for release in the summer.

As California's water resource systems face challenges from climate change and variability, so too do the State's agricultural sectors. Agricultural production is extremely vulnerable to climate change risks associated with unpredictable temperature and precipitation changes, with their consequent adverse effects on the state's water system.

Significant climate change could also impact many of California's species and ecosystems. Species differ significantly in their abilities to disperse and to become established in new locations with more suitable climates. With changes in climate, the extent of forested areas in California would also change. Hotter, drier weather would increase the frequency and intensity of wildfires, threatening both property and forests. Along the Sierra, drier conditions would reduce the range and productivity of conifer and oak forests. Farther north and along the northern coast, drier conditions would reduce growth of the Douglas fir and redwood forests. A significant increase in the extent of grasslands and chaparral throughout the State could result, with the consequence of greater wild fires. These changes would affect the character of California forests and the activities that depend on them.

In 2002, recognizing that global warming would impose compelling and extraordinary impacts such as these on California, its Legislature adopted and the Governor signed Assembly Bill 1493 (Chap. 200, Stats. 2002 (Pavley) – Attachment 3, item 1). AB 1493 directs the Board to adopt regulations that achieve the maximum feasible and cost effective reduction of greenhouse gas emissions from motor vehicles.

B. Emissions Regulated

Vehicular greenhouse gas emissions that contribute to climate change come from four main areas: (1) CO_2, CH_4, and N_2O emissions resulting directly from operation of the vehicle; (2) CO_2 emissions resulting from operating the air conditioning (AC) system (indirect AC emissions); (3) refrigerant emissions from the air conditioning system due to either leakage, losses during recharging, or release from scrappage of the vehicle at end of life (direct AC emissions); and (4) upstream emissions associated with the production of fuel used by the vehicle. The Greenhouse Gas Emission Standards account for all of these elements.

C. Regulatory Structure and Components

1. Fleet average standards

The Greenhouse Gas Regulations establish one manufacturer fleet average emission standard for passenger cars and the lightest trucks (PC and LDT1), and establish a separate manufacturer fleet average emission standard for heavier light-duty trucks (LDT2) and medium-duty passenger vehicles (MDPV). These standards are patterned after the LEV II declining fleet average NMOG standard. The Greenhouse Gas Regulations take effect on January 1, 2006 (13 CCR §1961.1(g)), and set near-term emission standards, phased in from 2009 through 2012, and mid-term emission standards, phased in from 2013 through 2016.

CARB identified a number of cost-effective technologies that are available to reduce motor vehicle greenhouse gas emissions sufficiently to allow compliance with the emission standards. Manufacturers can choose the mix of technologies that they will be able to employ, provided that the sales-weighted average emissions from their fleet meet the standards noted below. The standards are expressed in terms of CO_2-equivalent grams per mile, which means that emissions of the various greenhouse gases are weighted to take into account their differing impact on climate change.

The standards are as follows:

[See Next Page]

California's Greenhouse Gas Emission Standards

Year	Category		Standard (CO_2-eq g/mi)
2009	PC/LDT1	Near-term phase-in	323
	LDT2/MDPV		439
2010	PC/LDT1		301
	LDT2/MDPV		420
2011	PC/LDT1		267
	LDT2/MDPV		390
2012	PC/LDT1		233
	LDT2/MDPV		361
2013	PC/LDT1	Mid-term phase-in	227
	LDT2/MDPV		355
2014	PC/LDT1		222
	LDT2/MDPV		350
2015	PC/LDT1		213
	LDT2/MDPV		341
2016	PC/LDT1		205
	LDT2/MDPV		332

Like the LEV II NMOG fleet average standard, manufacturers can carry any debits forward, here for up to five model years. Manufacturers must then equalize any debits incurred within five years after they are generated.

2. Alternative fuel vehicles

To maintain simplicity, the regulation uses the upstream emissions certification value for vehicles that use conventional fuels as a "baseline" against which to compare the relative merits of alternative fuel vehicles. Therefore, the emissions standards as shown in the table above do not directly reflect upstream emissions for a vehicle certified using alternative fuels. Rather, when certifying gasoline or diesel-fuel vehicles, manufacturers will report only the "direct," or "on vehicle" emissions. For alternative fuel vehicles, exhaust CO_2 emission values will be adjusted to compensate for the differences in upstream emissions. This approach simplifies the regulatory treatment of gasoline vehicles, while at the same time allowing for appropriate treatment of alternative fuel vehicles.

3. Early credits

The California legislation authorizing these greenhouse gas regulations (AB 1493 (Pavley) – Attachment 3, item 1) directs that emission reduction credits be granted for any reductions in greenhouse gas emissions achieved prior to the operative date of the regulations. Under the regulation, credit for early emission reductions is available for model years 2000 through 2008, and the baseline against which manufacturer emissions are measured is the fully phased-in near-term standard for the 2012 model year. Manufacturers can bank any credits generated for their own later use, or for trading with other manufacturers.

4. Alternative compliance

AB 1493 also requires that the regulations provide compliance flexibility without undercutting the primary purpose of the regulations, which is to achieve greenhouse gas reductions from motor vehicles. Accordingly, the Greenhouse Gas Regulations feature an alternative compliance program that is limited to the vehicles that are regulated through AB 1493, and their fuels. The major features of the alternative compliance program are:

- Projects must be located in California to be eligible as alternative methods of compliance.
- Only companies regulated by AB 1493 (i.e., automakers) are permitted to generate and apply for alternative compliance credits.
- Only those vehicles regulated under AB 1493 are eligible for alternative compliance credits. This includes model year 2009 and later passenger vehicles and light-duty trucks and other vehicles used for noncommercial personal transportation in California.
- Eligible projects are limited to those that achieve greenhouse gas reductions through documented increased use of alternative fuels in eligible vehicles.

5. Test procedures

The Greenhouse Gas Rulemaking amended the LEV II test procedures to add greenhouse gases to those emissions for which manufacturers must submit test data at certification. As in the LEV program, for each greenhouse gas vehicle test group manufacturers must calculate both a "city" grams per mile average CO_2-equivalent value using the "FTP" test cycle (40 CFR, Part 86, Subpart B), and a "highway" CO_2-equivalent grams per mile average using the Highway Test Procedures' driving cycle. To ensure that vehicles are achieving maximum greenhouse gas reductions under all driving conditions, the city and highway values are combined in a 55/45 harmonic average. This average represents the national mix of urban and rural driving historically used by government agencies in reports relying on this statistic.[4]

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[4] The Greenhouse Gas Rulemaking noted the potential for improvements to driving cycles in the greenhouse gas test procedures. See Attachment 3, item 12, Agency Response to Comments 547 and 621. U.S. EPA is only in the early stages of exploring such improvements. See "EPA plans to revamp mileage testing," Boston Globe, September 18, 2005, available at

IV. CRITERIA FOR EVALUATING CALIFORNIA'S WAIVER REQUESTS

A. Statutory Criteria

Section 209(a) of the CAA provides that no state shall adopt or enforce any emission standard for new motor vehicles, and no state shall require certification, inspection, or any other approval relating to the control of emissions from any new motor vehicle as a condition of registration or titling in the state. However, section 209(b) directs the Administrator to waive federal preemption for new motor vehicle emission standards adopted and enforced by California[5] if the state determines that the state standards will be, in the aggregate, at least as protective of public health and welfare as applicable federal standards. The Administrator is to deny a waiver only if he finds, after a hearing: (1) that the protectiveness determination of the state is arbitrary and capricious; (2) that California does not need separate state standards to meet compelling and extraordinary conditions; or (3) that the state standards and accompanying enforcement procedures are not consistent with CAA section 202(a).

In Resolution 04-38, the Board made the determinations section 209 requires. See Attachment 3, item 7, p. 15. Therefore, authorization must be granted unless the Administrator makes one or more of the three findings enumerated in section 209(b)(1) of the CAA.

With regard to amendments that follow a previously granted waiver of federal preemption, the Administrator has stated that if California acts to amend a previously waived standard or accompanying enforcement procedure, the change may be included within the scope of the previous waiver if it does not undermine California's determination that its standards, in the aggregate, are as protective of public health and welfare as comparable federal standards, does not affect the consistency of California's requirements with section 202(a) of the Act, and raises no new issues affecting the Administrator's previous waiver determination.[6]

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http://www.boston.com/cars/articles/2005/09/18/epa_plans_to_revamp_mileage_testing/?page=2. See also "Mileage Numbers to Reflect Reality; EPA to Update Test Procedure," Washington Post, November 19, 2005, p. D01, available at http://www.washingtonpost.com/wp-dyn/content/article/2005/11/18/AR2005111802432.html. CARB will consider results of any resulting U.S. EPA rulemaking in any future CARB process to review or amend the Greenhouse Gas Regulations.

[5] The section 209(b) waiver provisions apply to any state that has adopted standards (other than crankcase emission standards) for the control of emissions from new motor vehicles or motor vehicle engines prior to March 30, 1966. (CAA §209(b)(1).) California is the only state that meets this condition. (S. Rep. No. 403, 90th Cong. 1st Sess., 532 (1967*); Motor and Equipment Manufacturers Ass'n v. EPA*, 627 F.2d 1095, 1100 note 1 (D.C.Cir. 1979) (*MEMA I*).

[6] Decision Document accompanying scope of waiver determination in 51 Fed.Reg. 12391 (April 10, 1986), at p. 2; see also 46 Fed.Reg. 36742 (July 15, 1981).

B. The Scope of the Waiver Hearing Is Limited

The scope of the Administrator's inquiry in determining whether to deny a waiver of federal preemption is limited by the express terms of section 209(b)(1). Thus, once California determines that its standards are, in the aggregate, at least as protective of public health and welfare as applicable federal standards, the Administrator must grant the authorization request unless one of the three specified findings can be made. This reading of the statute is consistent with the decision in *Motor and Equipment Manufacturers Association v. EPA*, 627 F.2d 1095 (D.C. Circuit 1979) (*MEMA I*) and prior U.S. EPA waiver decisions interpreting section 209(b), which hold that the review of California's decision to adopt separate standards is a narrow one.[7] As Administrator William D. Ruckleshaus stated in a 1971 decision:

> The law makes it clear that the waiver request cannot be denied unless the specific findings designated in the statute can properly be made. The issue of whether a proposed California requirement is likely to result in only marginal improvement in air quality not commensurate with its cost or is otherwise an arguably unwise exercise of regulatory power is not legally pertinent to my decision under section 209… .[8]

The express terms of section 209(b) combined with this and other waiver implementation history[9] thus establish that U.S. EPA cannot apply any additional criteria – such as potential conflicts with other law[10] – in evaluating California's waiver requests. U.S. EPA's review thus begins and ends with section 209(b).[11]

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[7] See 40 Fed.Reg. 23102, 23103 (May 28, 1975).

[8] 36 Fed.Reg. 17158 (August 31, 1971).

[9] 49 Fed.Reg. 18887-02, 18889 (May 3, 1984) and 58 Fed.Reg. 4166 (January 7, 1993), LEV I Decision Document, at pp. 20-21. See also 40 Fed.Reg. at 23104 (rejecting manufacturer arguments concerning potential fuel economy penalties as not controlling).

[10] *MEMA I,* 627 F.2d at 1114-20 (Administrator properly declined to review potential anti-trust and constitutional implications of CARB regulations under 209(b).)

[11] CARB anticipates that manufacturers will nevertheless attempt to raise issues in this proceeding concerning preemption under the federal Energy Policy Conservation Act (EPCA). These issues have been previously addressed in response to comments made in the Greenhouse Gas Rulemaking (See Attachment 3, item 12, pp. 358-368). They have also been addressed in the pending federal litigation (*Central Valley Chrysler-Jeep, Inc., et. al. v. Witherspoon*, Case No. 1:04-CV-06663 REC LJO, U.S. Dist. Ct. (E.Dist. CA – Fresno)) over the subject regulations, and in briefs California joined in filing in *Commonwealth of Massachusetts, et. al. v. U.S. Environmental Protection Agency*, 415 F.3d 50 (D.C. Cir. 2005). See Attachment 3, items 18 (pp. 38-44), 19 (pp. 17-21), and 20 (Tatel *dissent* at pp. 72-73), respectively. The CARB notes, however, that such issues are both outside the scope of the Administrator's review here as discussed in the text, and are irrelevant for the consistency analysis discussed in Section V.C. below.

C. Deference Must be Given to California's Policy Judgments

As indicated in the waiver decisions noted above, in granting waivers to California's motor vehicle program the U.S. EPA has routinely deferred to the policy judgments of California's decision makers. The U.S. EPA has recognized that the intent of Congress in creating a limited review of California's determinations that California needs its own separate standards was to ensure that the federal government not second-guess the wisdom of state policy.[12] Administrators have recognized that the deference is wide-ranging:

> The structure and history of the California waiver provision clearly indicate both a Congressional intent and an U.S. EPA practice of leaving the decision on ambiguous and controversial matters of public policy to California's judgment.
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> It is worth noting . . . I would feel constrained to approve a California approach to the problem which I might also feel unable to adopt at the federal level in my own capacity as a regulator. The whole approach of the Clean Air Act is to force the development of new types of emission control technology where that is needed by compelling the industry to "catch up" to some degree with newly promulgated standards. Such an approach . . . may be attended with costs, in the shape of a reduced product offering, or price or <u>fuel economy penalties</u>, and by risks that a wider number of vehicle classes may not be able to complete their development work in time. Since a balancing of these risks and costs against the potential benefits from reduced emissions is a central policy decision for any regulatory agency under the statutory scheme outlined above, I believe <u>I am required to give very substantial deference to California's judgments on this score.</u>[13]

This deference applies equally if not more so to policy considerations[14] over treatment of greenhouse gases. Section 209(b) continues to express Congressional intent for California to lead and experiment with the cutting edge of emission-reduction

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[12] 40 Fed.Reg. at 23103.

[13] 40 Fed.Reg. at 23104 (<u>emphases</u> added). See also 58 Fed.Reg. 4166, LEV I Decision Document, at p. 64.

[14] The Court's holding in *Massachusetts v. Environmental Protection Agency* states only that EPA could permissibly decide not to regulate greenhouses gases from motor vehicles at a given point in time due to a combination of policy considerations. 415 F.3d 50, 56-58 (D.C. Cir. 2005). Attachment 3, item 20. Though under this opinion U.S. EPA can exercise policy discretion to not regulate certain vehicular emissions federally, it must continue evaluating California's regulation of those same emissions through a different lens.

technologies.[15] This has often necessarily included technologies that both reduce federally-regulated emissions and reduce emissions of types that U.S. EPA has yet to choose to regulate.[16] Just as California paved the way for tremendous advances in reducing criteria pollutant emissions, California's Greenhouse Gas Regulations are promoting advances in reducing climate-changing greenhouse gas emissions.

D. The Burden of Proof Is On Those Opposed to the Waiver Request

As stated above, under section 209(b), the Administrator can deny a waiver or an authorization if, and only if, he makes one of the three findings enumerated therein. In interpreting the language of 209(b), it has been held that the burden of proof to show that there is a basis for making one of the three findings is squarely on the opponents of a waiver. As the appellate court stated in *MEMA I* at 1120-21:

> It is not necessary for the Administrator affirmatively to find that these conditions do not exist before granting a waiver. The statute does not say "the Administrator shall grant a waiver only if" he makes the negative of these findings. That he must deny a waiver if certain facts exist does not mean that he must independently proceed to make the opposite of those findings before he grants the waiver regardless of the state of the record . . . .The language of the statute and its legislative history indicate that California's regulations, and California's determination that they comply with the statute, when presented to the Administrator are presumed to satisfy the waiver requirements and that the burden of proving otherwise is on whoever attacks them. California must present its regulations and findings at the hearing, and thereafter the parties opposing the waiver request bear the burden of persuading the Administrator that the waiver request should be denied.

And to best accord with Congressional intent, challengers must meet this burden with clear and convincing evidence as to the protectiveness of California's motor vehicle standards as a whole, and with an elevated standard of proof for the other waiver considerations.[17]

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[15] "Congress intended [California] to continue and expand its pioneering efforts at adopting and enforcing motor vehicle emission standards different from and in large measure more advanced than the corresponding federal program." *MEMA I,* 627 F.2d at 1110-11. *Accord*, *Motor and Equipment Manufacturers Association v. Nichols,* 142 F.3d 449, 463 (D.C. Cir. 1998) *(MEMA II)*.

[16] Congress intended for California's standards to be "more stringent than, or applicable to emissions or substances not covered by, the national standards." H.R. Rep. No. 90-728 (1967), reprinted at 1967 U.S.C.C.A.N. 1938, 1958.

[17] "Although *MEMA I* did not explicitly consider the standard of proof under Section 209 in connection with a waiver request for 'standards,' there is nothing to suggest that the court's analysis would not apply with

E. The 1990 Clean Air Amendments Solidified the Above Principles

The 1990 Clean Air Act Amendments added to California's on-road authority a provision authorizing California to adopt its own emission standards for nonroad vehicles and engines. In doing so, Congress established requirements for U.S. EPA review of authorizing requests under section 209(e)(2) nearly identical to the longstanding 209(b)(1) requirements. Congress unmistakably intended that the U.S. EPA accord similar deference to California's decisions under 209(e)(2).[18] Conversely, in passing the 1990 Clean Air Act Amendments, no changes were made to section 209(b), indicating Congressional approval of over two decades of EPA waiver decision-making and related court doctrine.

V. A PROPER APPLICATION OF WAIVER LAW AND PRINCIPLES REQUIRES U.S EPA TO GRANT THIS REQUEST BECAUSE THE RECORD PROVIDES NO BASIS FOR DENIAL

With the above criteria in mind, CARB believes that their proper application can result only in the Administrator of U.S. EPA granting a waiver of preemption.

A. Protectiveness

In Resolution 04-38, the Board made the protectiveness determination that section 209(b) requires. See Attachment 3, item 7, p. 15, and related finding on p. 13. This determination was simple, as there are no federal standards regulating greenhouse gases from motor vehicles against which to compare California's greenhouse gas emission standards. In fact, U.S. EPA has explicitly declined to regulate vehicular greenhouse gas emissions (68 Fed.Reg. 54922 (September 8, 2003)), and has not stated there or elsewhere that it was declining to regulate, in whole or in part, because another federal agency had sole authority to regulate any or all of those gases.[19] And

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equal force to such determinations." 61 Fed.Reg. 53371 (October 11, 1996) (*OBD II*), Decision Document at p. 14. *Accord*, 49 Fed.Reg. at 18888 and 58 Fed.Reg. 4166 (January 7, 1993) (*LEV I)* Decision Document at pp. 19-20. As to protectiveness, see also H.R. Rep. No. 95-294 at 301-302 (1977), reprinted at 1977 U.S.C.C.A.N. 1077 ("There must be clear and compelling evidence that the state acted unreasonably in evaluating the risk of various pollutants in light of the air quality, topography, photochemistry, and climate in [California], before EPA may deny a waiver.")

[18] See discussion in *Engine Manufacturers Association v. U.S. EPA*, 88 F.3d 1075, 1090 (D.C. Cir. 1996) (*EMA*), wherein the court recognized California's leadership in emission control regulation in both new motor vehicles and new and in-use nonroad engines.

[19] While it is true that as a result of federal fuel economy standards fleet average vehicular greenhouse gas emissions – primarily CO_2 – have been reduced over time, this has been a fortunate emission reduction benefit, but not the purpose, of the EPCA statute authorizing National Highway Traffic Safety Administration's (NHTSA) Corporate Average Fuel Economy (CAFE) standards.

CARB is not aware of any waiver or authorization proceeding in which U.S. EPA evaluated any federal standards other than its own for protectiveness.

The structure of section 209(b) demonstrates that "…applicable Federal standards…" refers only to EPA-promulgated standards. The repetition of that phrase in Section 209(b)(2) and 209(b)(3) makes clear that in determining whether California has acted arbitrarily or capriciously in making its finding of protectiveness, the Administrator has been directed by Congress to only compare California's standards to those standards for which U.S. EPA has primary expertise (i.e., motor vehicle emissions standards). This must have been Congress' intent in fashioning the criterion of section 209(b)(1); otherwise it could be argued that California acts arbitrarily and capriciously if California's protectiveness finding must be compared to and account for any federal statute that has an effect on a motor vehicle's emission standards. For example, it could be argued that CARB failed to consider federal highway legislation that reduces traffic congestion,[20] which could directly or indirectly result in lower criteria pollutant emissions, just as CAFE standards could impact resulting greenhouse gas emissions. Section 209(b) does not task U.S. EPA with such a broad-based inquiry into equivalency with these or other federal standards; it simply requires U.S. EPA to briefly examine California's protectiveness determination under the highly deferential "arbitrary and capricious" standard.[21]

Again, since U.S. EPA has declined to set federal standards for greenhouse gases, California's Greenhouse Gas Regulations are unquestionably at least as protective as the applicable federal standards, since the latter do not exist. And even if EPA were to countenance manufacturer arguments that these Greenhouse Gas Emission Standards undermine the protectiveness of LEV II and other California standards, there remains no

[20] 23 U.S.C. § 149 (Congestion Mitigation and Air Quality Improvement (CMAQ) program). CARB also notes that this and other statutes allow regulation of motor vehicle emissions though they might impact fuel economy, and such statutes are not novel or limited to the 209(b) context. Elsewhere in the Clean Air Act Congress provided examples of emission reduction measures that would no doubt improve fuel economy. See e.g. the transportation control measures at Clean Air Act subsections 108(f)(1)(A)(v) (traffic flow improvements) and (xi) (extended idling). Whether enacted to meet these Clean Air Act requirements or for other purposes (see 13 CCR, sections 2480 and 2485 to reduce airborne toxic emissions), numerous state and local measures notably affect fuel use and resultant fuel economy, though that is not their purpose and intent. But whatever the purpose of these other standards or measures, U.S. EPA's task is a simple one, limited to determining protectiveness vis a vis its own emission-control standards.

[21] Even if U.S. EPA thought, contrary to its limited role under section 209(b), that it was appropriate to tread into other federal agencies' territory, or thought it appropriate to give much weight to other federal agency comments (e.g. potentially from NHTSA) that might be entered in this matter, the Greenhouse Gas Rulemaking clearly demonstrates that such comparisons are fruitless. See Attachment 3, item 12, Agency Responses to Comments 534, 539, 589, and 591 (second paragraph). See also Attachment 3, item 21, Declaration of Steve Albu, paragraphs 24-30.

question that California's new motor vehicle program as a whole[22] would be at least as protective of the public health and welfare as the applicable Federal standards. Therefore there is simply no competing evidence to suggest that the Board could have been arbitrary and capricious in its protectiveness determination, and U.S. EPA cannot deny the waiver on that basis.

B. California Needs Separate State Standards to Meet Compelling and Extraordinary Circumstances

California needs its own engine and vehicle programs to meet serious air pollution problems unique to the State. The Administrator has previously and consistently recognized California's unique needs when granting waivers for motor vehicles under section 209(b) and authorization for California's nonroad regulations under section 209(e) of the CAA.

The relevant inquiry under section 209(b)(1)(B) is whether California needs its own emission control program to meet compelling and extraordinary conditions, not whether any given standard is necessary to meet such conditions.[23] In approving waivers under section 209(b), the Administrator has determined that:

> "compelling and extraordinary conditions" does not refer to levels of pollution directly, but primarily to the factors that tend to produce them: geographical and climatic conditions that, when combined with large numbers and high concentrations of automobiles, create serious air pollution problems.[24]

In the California Clean Air Act of 1988, the California Legislature found that:

> despite the significant reductions in vehicle emissions which have been achieved in recent years, continued growth in population and vehicle miles traveled throughout California have the potential not only to prevent

[22] Trade-offs between emissions are permissible so long as "the entire set of [California] standards are at least as protective of the public health and welfare as the Federal standards." (H.R. Rep. No. 95-294 at 301-302 (1977), reprinted at 1977 U.S.C.C.A.N. 1077).

[23] The Administrator has recognized that even if such a standard by standard test were applied to California, it "would not be applicable to its fullest stringency due to the degree of discretion given to California in dealing with its mobile source pollution problems," 41 Fed.Reg. 44209, 44213-15, (October 7, 1976). See also 49 Fed. Reg. 18887, 18890 (May 3, 1984) (finding Congressional intent precludes U.S. EPA from viewing adopted California vehicular particulate matter standard in isolation).

[24] 49 Fed.Reg. at 18890. There the Administrator found that California need not demonstrate its particulate problem (or diesel vehicles' contribution to it) is the worst in the country in order to adopt a particulate matter standard affecting diesel vehicles. *Id.* at 18891-92.

> attainment of the state standards, but in some cases, to result in worsening of air quality.[25]

In response to the undisputed severe air quality problems in California, the California Legislature provided CARB with broad authority to regulate on- and off-road engines and other sources to meet federal and state air quality standards.[26] California – the South Coast and San Joaquin Valley Air basins in particular – continues to experience some of the worst air quality in the nation.[27] California's ongoing need for dramatic emission reductions generally and from passenger vehicles specifically is abundantly clear from its recent adoption of state implementation plans for the South Coast and other California air basins.[28] The unique geographical and climatic conditions, and the tremendous growth in vehicle population and use that moved Congress to authorize California to establish separate vehicle standards in 1967, still exist today. Note that U.S. EPA recently confirmed CARB's judgment, on behalf of the State of California, on this matter.[29]

Nothing in these conditions has changed to warrant a change in such confirmation by U.S. EPA. Longstanding federal waiver law and practice makes clear that in reviewing California's waiver requests, U.S. EPA is not to micro-manage each California standard for each pollutant regulated in its mobile source programs. 58 Fed.Reg. 4166 (January 13, 1993), LEV I Decision Document at 53-57, citing 36 Fed. Reg. 17458 (August 31, 1971). Rather, under a narrow standard of review (49 Fed.Reg. 18887 at 18890 (May 3, 1984)), the burden is on waiver opponents (LEV I Decision Document at 18-26) to show that California no longer has a compelling need, informed by its own circumstances and the benefits that would accrue to it and other states, to maintain its own motor vehicle program as a whole (LEV I Decision Document at pp. 46-52). Therefore, California need not demonstrate in this rulemaking that the state faces unique threats from greenhouse gas emissions. And California clearly continues to face extraordinary and compelling conditions generally.

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[25] California Health and Safety Code section 43000.5.
[26] California Health and Safety Code sections 43013 and 43018.
[27] See e.g. Approval and Promulgation of State Implementation Plans; California – South Coast, 64 FR 1770, 1771 (January 12, 1999). See also 69 Fed. Reg. 23858, 23881-90 (April 30, 2004) (designating 15 areas in California as nonattainment for the federal 8-hour ozone national ambient air quality standard).
[28] See, e.g., "2003 State and Federal Strategy for the California SIP," Executive Summary, available at http://www.arbCARB.ca.gov/planning/sip/stfed03/stfed03.htm.
[29] "CARB has continually demonstrated the existence of compelling and extraordinary conditions justifying the need for it own motor vehicle control program, which includes the subject 2007 California Heavy Duty Diesel Engine Standards." *California State Motor Vehicle Pollution Control Standards; Waiver of Federal Preemption; Notice of Decision,* 70 Fed.Reg. 50322, 50323 (August 26, 2005) (emphasis added).

Although manufacturers disputed CARB's analyses, the Greenhouse Gas Rulemaking shows that while the regulations are primarily aimed at controlling greenhouse gases, they will also produce a slight reduction in criteria pollutants.[30] Given the limited scope of the hearing,[31] this marginal improvement in criteria pollutant emissions[32] suffices to show that these Greenhouse Gas Regulations are part of a motor vehicle control program that contributes toward improved air quality.

Nonetheless, manufacturers may continue to argue that Congress intended California's mobile source program, like U.S. EPA's, to address only criteria pollutants having a more direct and localized impact, and not to address pollutants presenting climate concerns. Though not binding, the only opinion to address this argument – and limited exclusively to U.S. EPA's role – soundly rejects it for several compelling reasons.[33] One reason is that the plain meaning of "pollutant" under the act clearly covers greenhouse gases.[34] Another reason is that specific 1990 Clean Air Act Amendments mentioning more limited research and study cannot trump the more general grant of authority to adopt emission standards provided in section 202(a).[35] The opinion gives many more reasons, but no more are needed here; given the broad deference accorded to California's policy determinations mentioned above, any of this reasoning would suffice to further support California's continuing demonstration of extraordinary and compelling conditions justifying a need for its own motor vehicle control program, which now includes reductions in greenhouse gas emissions.

Manufacturers may also continue to argue that California's position vis-a-vis other states regarding climate change impacts is not "extraordinary." This is not legally pertinent to the Administrator's review of California's continuing need for its own motor vehicle program.[36] Even so, California's Legislature recognized,[37] and the rulemaking record provides strong evidence for, extraordinary and compelling conditions in

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[30] Attachment 3, item 3, pp. 146-147 and item 5, p. 18.
[31] See *supra* note 8 and accompanying text.
[32] Or even a slight detriment, if proven; see *supra* note 22 and accompanying text.
[33] *Massachusetts v. Environmental Protection Agency*, 415 F.3d 50, 67-73 (D.C. Cir. 2005) (Judge Tatel *dissenting*). Available at Attachment 3, Item 20. CARB notes that neither U.S. EPA's current position on the "pollutant" question nor any further judicial resolution of that issue is relevant to California's authority over the same pollutant(s). See *supra* note 16 and *infra* note 43. CARB also notes that pollutants currently regulated by both U.S. EPA and CARB, e.g. particulates, can and do cross international boundaries, sometimes across oceans. Further, while particulates were not incorporated into the subject Greenhouse Gas Emissions Standards, some forms of them could potentially impact climate change.
[34] 415 F.3d. at 68-69. To its credit, the controlling opinion by Judge Randolph (415 F.3d 50, 53-59) did not even attempt to justify its holding on the "pollutant" issue.
[35] 415 F.3d. at 71-72.
[36] As the Administrator has stated, "there is no indication in the language of Section 209 or the legislative history that California's pollution problem must be the worst in the country, for a waiver to be granted…" 49 Fed.Reg. 18887, 18891 (May 3, 1984).
[37] Attachment 3, item 1, SEC. 1, (d) (findings).

California due solely to global warming from greenhouse gas emissions. In particular, while California's coastal resources are threatened like those in other states, California is particularly vulnerable in its Bay-Delta area to saltwater intrusion from sea-level rise, levee collapse, and flooding, any of which would severely tax California's increasingly fragile water-supply system. The predicted decrease in winter snow pack would exacerbate these impacts by reducing spring and summer snowmelt runoff critical for municipal and agricultural uses, a situation further strained by fish and wildlife considerations.[38] Also, of course, California's high ozone levels – clearly a condition Congress considered – will be exacerbated by higher temperatures from global warming. This crucial need for greenhouse gas reductions from passenger vehicles is repeatedly referenced in the subject rulemaking.[39] Thus California's circumstances are no less extraordinary and compelling than those it faced when Congress first recognized and provided for California's separate motor vehicle emission control program.

Finally, the Administrator must reject any argument from manufacturers that California's Greenhouse Gas Regulations are not "necessary" because California cannot demonstrate the exact degree to which they will reduce temperatures and other adverse impacts in California. This issue is likewise not legally pertinent to the Administrator's review of California's continuing need for its own motor vehicle program. Again, California's policy judgment that even a minimal directional improvement will occur and is worth pursuing is entitled to great deference.[40] In addition, the argument proves too much, since to our knowledge, no current greenhouse gas reduction strategy considered anywhere in the world could make that demonstration, yet measures applying to this and other greenhouse gas emission sources are being considered and adopted worldwide. And by comparison, neither federal nor state criteria pollutant regulations – including waived California passenger vehicle standards and states' adopted SIP measures – attempt to quantify the actual local change in ambient ozone or secondary particulate matter levels from each individual measure; it is enough that such measures contribute limited but important emission reductions.[41]

For example, numerous state, federal and local control measures reduce ozone precursors that then ultimately lead to lower ozone levels. Likewise, here numerous state, local, international and hopefully U.S. control measures will reduce greenhouse

[38] See e.g. Attachment 3, item 3, pp. 19-25, Attachment 3, item 12, pp. 54-100, and Hayhoe et. al. PNAS August 24, 2004, vol. 101, no. 34, pp. 12422–12427 (as listed in Attachment 3, item 9, Attachment II thereto).
[39] Resolution 04-28 (Attachment 3, item 7) at pp. 3, 6. See also Staff Report: Initial Statement of Reasons (Attachment 3, item 3) at pp. 14-16 and 44-49.
[40] *Supra* notes 12-15 and accompanying text.
[41] While emission reductions from all sources are modeled for attainment demonstrations, the complexity of such modeling does not allow one to tie a specific emission reduction measure with a specific, incremental drop in ambient pollutant concentrations.

gases and the resultant global warming that increases ozone formation, among other impacts. As stated, California has a compelling and extraordinary need for the adopted regulations, especially since current SIP modeling demonstrations assume that temperatures – and their detrimental effect on ozone chemistry, per capita air conditioning demand and resulting increased power plant NOx emissions, evaporative emission rates, and biogenic hydrocarbon emissions – and global ozone background levels are unchanged in the future. Any future incorporation of such modeling considerations would only increase the necessity of these regulations – and many other greenhouse gas emission reduction measures – to reduce adverse public health and other impacts.

For all the aforementioned reasons, there can be no doubt of the continuing existence of compelling and extraordinary conditions justifying California's need for its own passenger vehicle program, of which these Greenhouse Gas Regulations are now part. U.S. EPA thus cannot deny the waiver on this basis either.

C. Consistency With Clean Air Act Section 202(a)

With regard to the consistency issue, the Administrator has stated that California's standards and accompanying test procedures are inconsistent with section 202(a) if: (1) there is inadequate lead time to permit the development of technology to meet those requirements, giving appropriate consideration to the cost of compliance within that time frame; or (2) the federal and California test procedures impose inconsistent certification requirements so as to make manufacturers unable to meet both sets of requirements with the same vehicle.[42] As the following discussion demonstrates, the Greenhouse Gas Regulations are fully consistent with section 202(a) of the CAA.[43]

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[42] "Neither the court nor the agency has ever interpreted compliance with section 202(a) to require more." *MEMA II*, 142 F.3d at 463 (citations omitted). See also 46 Fed.Reg. 26371 (May 12, 1981). Even where there is incompatibility between the California and federal test procedures, EPA has granted a waiver under circumstances where EPA accepts a demonstration of federal compliance based on California test results, thus obviating the need for two separate tests. (43 Fed.Reg. 1829, 1830 (January 12, 1978); 40 Fed.Reg. 30311, 30314 (July 18, 1975).)

[43] We anticipate that manufacturers will nevertheless continue to argue that a California standard regulating greenhouse gases cannot be "consistent with" section 202(a) if U.S. EPA has not yet chosen to regulate those emissions under that section, or because U.S. EPA could not adopt the same kind of greenhouse gas reducing air conditioning standards as California has. CARB's previous response to these arguments is provided at Attachment 3, item 12, pp. 355-358. Simply put, for all the reasons Judge Tatel indicated (415 F.3d at 67-73 (J. Tatel *dissenting*), Attachment 3, Item 20), California believes U.S. EPA's current position on its authority to regulate greenhouse gas emissions under section 202(a) is untenable. See also *supra* notes 33-35 and accompanying text. Even if U.S. EPA's current view withstands any further judicial scrutiny following the D.C. Circuit action, U.S. EPA cannot read section 202(a) in isolation when reviewing a waiver requested under 209(b). Congress had just two aims with section 209(b): 1) to protect manufacturers from having to create a "third car," while; 2) allowing – indeed encouraging – California to blaze its own trail with its motor vehicle program as a whole, at times

1. TECHNOLOGICAL FEASIBILITY AND LEAD TIME

Section 202(a)(2) provides that a regulation shall take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance. In making determinations under section 209(b)(1)(C), the Administrator has relied upon federal court decisions applying the requirements of section 202(a)(2) to federal standards. The leading federal cases construing section 202(a)(2) are *Natural Resources Defense Council v. U.S. EPA*, 655 F.2d 318 (D.C. Cir. 1981) (*NRDC*) and *International Harvester Co. v. Ruckleshaus*, 478 F.2d 615 (D.C. Cir. 1973) (*International Harvester*).

NRDC makes clear that Congress intended U.S. EPA to project future advances in pollution control technology rather than be limited to the technology existing when the standards were set.[44] The *NRDC* court noted that a longer lead time "gives the U.S. EPA greater scope for confidence that theoretical solutions will be translated successfully into mechanical realizations."[45] In addition, "[t]he presence of substantial lead time for development before manufacturers will have to commit themselves to mass production of a chosen prototype gives the agency greater leeway to modify its standards if the actual future course of technology diverges from expectation." (*Id.*) The court concluded:

> We think that the U.S. EPA will have demonstrated the reasonableness of its basis for prediction if it answers any theoretical objections to the [projected control technology], identifies the major steps necessary in refinement of the [technology], and offers plausible reasons for believing that each of those steps can be completed in the time available.[46]

The emission standards and related requirements adopted in the subject rulemaking satisfy the criteria set forth in the *International Harvester* and *NRDC* cases. In both its Initial Statement of Reasons for Rulemaking (Attachment 3, item 3), and Final Statement of Reasons (Attachment 3, item 12), CARB either has demonstrated that the necessary technology presently exists to meet the established standards or has

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regulating vehicular emissions before they are regulated federally. See s*upra* notes 15 and 16, Section 209(b) history summarized at 88 F.3d at 1079-80, and 88 F.3d at 1089-90 (wherein court agreed with industry position that nonroad authorization process parallel to 209(b) requires EPA to review California regulation not within the EPA's own regulatory authority). For these reasons, U.S. EPA's current position as reflected in its 202(a) decision simply does not apply to its review of this request under Section 209(b).

[44] 655 F.2d at 328.

[45] *Id.* at 329.

[46] *Id.* at 331-32. *Accord*, *Husqvarna AB v. Environmental Protection Agency*, 254 F.3d 195, 201 (D.C. Cir. 2001) and *National Petrochemical & Refiners Association v. Environmental Protection Agency*, 287 F.3d 1130, 1136 (D.C. Cir. 2002).

specifically identified the projected control technologies, answered objections raised by industry regarding that technology, and has explained its reasons for believing that each of the steps can be completed in the time available. And unlike most previous CARB requests setting standards years into the future, each of the technology packages projected for compliance contains many technologies that are currently available and in vehicles today. The only relevant question, then, is whether manufacturers can apply these technologies in sufficient quantities to meet the standards in time for the regulatory compliance deadlines following model years 2012 and 2016, a lead time of eight to 11 years respectively. The Greenhouse Gas Rulemaking record shows that they can.

a. Greenhouse Gas Emission Reduction Technologies

As discussed in the Staff Report (Attachment 3, item 3, pp. 48-57 and Table 5.2-3), potential greenhouse gas reduction technologies break down into roughly four areas: (1) Engine, Drivetrain, and Other Vehicle Modifications – valvetrain, transmission, vehicle accessory, hybrid-electric, and overall vehicle modifications designed to reduce engine exhaust CO_2 emissions from conventional vehicles;[47] (2) Mobile Air-Conditioning System – air conditioning unit modifications to reduce vehicle CO_2 emissions and modifications (e.g., improved containment of refrigerant, alternative refrigerants) to reduce emissions of HFC refrigerants, such as HFC-134a; (3) Alternative Fuel Vehicles – the use of vehicles that use fuels other than gasoline and diesel to reduce the sum of exhaust emissions and "upstream" fuel-delivery emissions of climate change gases; and (4) Exhaust Catalyst Improvement – exhaust aftertreatment alternatives to reduce tailpipe emissions of CH_4 and N_2O.

In each of the above four areas, several technologies stood out as providing significant emission reductions at favorable costs. These include dual cam phasing, turbocharging with engine downsizing, automated manual transmissions, and camless valve actuation. Potential improvements in the air conditioning system include an improved variable

[47] Manufacturers have made much of the fact, and U.S. EPA has noted (68 Fed. Reg. 52922, 52929 (September 8, 2003)), that there are currently no effective aftertreatment devices to control greenhouse gases. But this was and is unremarkable, as one focus of vehicular criteria pollutant control has been, as here, on engine modifications that would reduce engine-out emissions. For example, in the early years of emission control, manufacturers relied on non-catalyst technologies such as exhaust gas recirculation (EGR) and retarded timing to reduce NOx emissions. More recently, manufacturers have invested significant resources to reduce engine out emissions to meet the LEV requirements. Individual air-fuel control, adaptive fuel control systems, electronic throttle control systems, fuel injection, and dual and universal oxygen sensors, all serve to reduce engine out emissions not only of criteria pollutants, but also of CO_2. U.S. EPA has already waived preemption of the California standards that assume manufacturers will use these technologies. See *supra* notes 1 and 3. And U.S. EPA's Tier II passenger vehicle standards assume manufacturers will use many of these same CO_2–reducing technologies.

displacement compressor with revised controls, reduced leakage systems, and the use of an alternative refrigerant (e.g. HFC-152a). The rulemaking demonstrates that packages containing these and other technologies can provide substantial emission reductions, at costs ranging from a vehicle cost savings to a few hundred dollars. Nearly all technology combinations modeled provide reductions in lifetime operating costs that exceed the retail price of the technologies.

Engine Valvetrain Modification – Valve Lift and Cam Phasing

Valve timing and lift have historically been fixed for most manufacturers regardless of vehicle load demand. Variable valve timing, also known as "cam phasing," and variable valve lift can improve engine CO_2 emissions by more optimally managing precisely when the valves open and close and exactly how much they open and close. Cam phasing can be varied either by linking the intake and exhaust cams together and rotating them with one phaser (CCP) or independently using dual cam phasers (DCP) for varying engine operation conditions. Valve lift technologies can be introduced to make continuous variations in lift (CVVL), or to make incremental discrete valve height lifts (DVVL). These technologies can also be introduced either singly or in combination, providing reduced engine pumping losses, improved power output that permits engine downsizing, and substantial CO_2 reductions.

Turbocharging With Engine Downsizing

In conventional gasoline-fueled passenger vehicles, air-fuel mixture (i.e. "charge") enters the cylinders near ambient pressure. Increasing, or "boosting," the pressure of the air-fuel mix in the cylinder results in a higher specific power output from the engine. Therefore, the use of a turbocharging compressor to increase the charge entering the cylinders improves engine power output and offers the opportunity to downsize the engine without compromising vehicle performance, thereby allowing operation of the engine in more optimal, low-CO_2 regions. A turbocharger system uses the otherwise lost thermal energy of the exhaust to operate a turbine, which then drives a compressor. Current state-of-the-art turbocharging systems chargers incorporate a variable geometry feature that provides quicker boost at all speeds to maintain performance from downsized engines, especially at lower speeds where "turbo lag" can otherwise result in sluggish performance. Turbochargers operate best on direct injection engines that minimize the chargers' tendency to "knock" while retaining relatively high compression ratios for optimal performance.

Automated Manual Transmissions

Automatic transmissions on today's vehicles generally have 4 gear ratios, or speeds. Increasing the number of gears to 5- or 6-speeds, as has already been done in numerous vehicle models, allows the engine to operate in more optimum ranges for lowest CO_2 emissions during the drive cycle. Each increase in number of speeds corresponds approximately to a two percent reduction in CO_2 emissions. More advanced transmissions may offer more substantial improvements. The automated manual transmission (AMT) acts like a conventional automatic transmission in that shifting is performed automatically, but without a torque converter. AMTs with a dual wet clutch system provide shift quality that equals or exceeds the smoothness of current automatic transmissions.[48]

Camless Valve Actuation

Camless valve actuation (CVA) systems replace a belt, chain- or gear-driven camshaft system with variable electrohydraulic or electromagnetic actuation of the valves. Camless valve actuation is the ultimate goal of engine designers to achieve optimum valve position and lift for maximum engine performance and lowest CO_2 emissions over the full range of engine operation. Engines with CVA systems do not need a throttle and can deactivate cylinders anytime as opportunity exists. Significant CVA development activity is taking place in Europe and Japan. Manufacturers that develop this technology and enter the market early will have a strong competitive advantage. It also represents a more logical next step for manufacturers in that overhead cam designs would likely be short-lived should CVA come to fruition as early as the 2010 timeframe as is now predicted.[49]

Gasoline Direct Injection

Conventional gasoline engines inject fuel into the intake manifold ahead of the intake valve, wherein fuel evaporates and is inducted into the cylinder with the incoming air. Directly injecting the fuel into the cylinder produces a cooling effect whereby engine compression ratios can be safely increased without inducing pre-ignition. As a result, higher specific outputs can be achieved from the engine, thereby allowing the full benefits of engine downsizing to be realized.[50]

Engine-Friction Reduction

Due to the large number of internal parts in today's engines coupled with numerous accessory drives, continued improvements in engine-friction reduction by advanced design of engine components and subsystems should result in improved engine operation and reduced climate change emissions. Continued friction reductions can be achieved by reducing engine component weight, by using improved or different materials, by more optimal thermal management, and by improving computer-aided

[48] For a recent discussion of dual-clutch transmission progress, see Attachment 3, Item 22.
[49] For a recent discussion of camless valve actuation progress, see Attachment 3, Item 23.
[50] For a recent discussion of gasoline direct injection progress, see Attachment 3, Item 24.

understanding of component dynamics under various engine load and vibration conditions. Further friction reductions should also result from the use of advanced multi-viscosity engine and transmission oils.

Aerodynamic Drag and Rolling Resistance

Improvements in aerodynamic drag and rolling resistance can reduce the overall force required to propel a vehicle, reducing engine load and leading to a reduction in vehicle exhaust CO_2 emissions. Two ways to reduce the engine load for a given vehicle are to reduce the opposing resistance or frictional forces that act against the motion of the vehicle. Two prominent resistance forces are aerodynamic drag and rolling resistance from the tires. The most obvious areas for potential aerodynamic drag improvements are reducing the frontal area of the vehicle or improving the shape of the body, with skirts, air dams, underbody covers, and other features that have less aerodynamic friction. The rolling resistance force due to deflection of the sidewalls as they roll can be improved via shoulder design improvements or with design and material modifications to the tire tread pattern, tire belts, or the traction surface.

More Aggressive Shift Logic

Applying more aggressive shift logic, by shifting the engine speeds at which automatic transmissions switch from one gear ratio to another, can have a substantial impact on CO_2 emissions. Using more aggressive shift logic allows more flexible shifting of gears and thus allows for operation of the engine at more optimal low CO_2 emission regions of the engine maps. Generally, aggressive shift logic entails moving up transmission shift points to lower speeds and reducing the amount of downshifting. Drivability and acceleration concerns must be accounted for carefully in these alterations of shifting schedules.

Early Torque Converter Lockup

Applying early torque converter lockup on automatic transmissions can also reduce greenhouse gas emissions. Conventional automatic transmissions employ a torque converter between the engine and transmission. This is a fluid coupling with hydraulic torque multiplication capability that helps provide a brisk "launch feel" to vehicles so-equipped. They also dampen engine vibrations in the driveline and allow engines to remain at idle speeds with the transmission engaged in a forward or reverse gear. Unfortunately, the torque multiplication at launch and the other features result in higher CO_2 emissions compared to a manual transmission. In order to reduce slip, virtually all of today's automatic transmissions offer some degree of lock-up capability during some light accelerations and during cruise conditions (this means the torque converter no longer slips needlessly and provides direct or near-direct mechanical transmission of power to the drive wheels much like a manual transmission). The conditions under which lockup operation occurs can be improved by doing so earlier than at present, especially when the number of transmission speeds increases, thereby reducing CO_2 emissions. As with early shift speeds, however, care must be exercised to ensure smooth, responsive drivability and low noise, vibration, and harshness. CARB relied upon conservative modeling assumptions to ensure good drivability and minimum vibration.

Other Potential Engine-Based Technologies

CARB projected that manufacturers may use other technologies staff identified but that did not rank among those most likely to be implemented cost-effectively. These include hybridization and greater dieselization of the fleet.

Hybridization. Hybridization uses both combustion engines and electric motors for propulsion and is being actively explored by all major auto manufacturers. Hybridization of current and planned vehicles varies widely from "mild" hybrids, which tend to be more similar to conventional gasoline passenger vehicles, to fully-integrated "advanced" hybrids that use and store more electric energy on-board. Differentiating the mild system from more advanced hybrids is the increased extent to which electrical power is stored on the vehicle and used during driving. In a fully integrated hybrid (e.g., Toyota Prius), the electric motor approaches the same size as the on-board combustion engine and therefore can be used exclusively to power the vehicle during low-load, low speed conditions. In the moderate "motor-assist" hybrid configuration, such as the Honda Civic Hybrid, the maximum power output of the engine is substantially greater than that of the electric motor. The electric motor then is generally used for times of higher load demands, such as acceleration or hill climbing, providing for engine downsizing and optimization for low load conditions such as cruising. Mild hybrids generally offer only idle off capability. Compared with similar performing conventional vehicles, moderate to aggressive hybrids can achieve improvements of over thirty percent in CO_2 emissions. Along with the commercially available Toyota and Honda hybrid vehicles, every major automaker has plans to produce hybrid vehicles in the next few years. EPA is investigating the potential of hydraulic hybrids and has published an interim report on their progress. See http://www.epa.gov/otaq/technology/index.htm and specifically "Progress Report on Clean and Efficient Automotive Technologies Under Development at EPA: Interim Technical Report" (PDF, 198 pages, 2.5M) (EPA420-R-04-002, January 2004).

Greater Dieselization

High speed direct injection (HSDI) diesel vehicles have improved with the advancement of several technologies. Diesel compression-ignition engines, with higher compression ratios, turbocharging, and lean air-fuel ratios provide significant CO_2 reductions compared with conventional gasoline engines. Advancements in small diesel engines running at high speeds (over 4000 rpm compared to heavy-duty diesel engines at about 2500 rpm) in the areas of fuel injection, emissions, noise, and vibration have addressed many of the more objectionable aspects of these vehicles, making them more acceptable to the public. Diesel vehicles are popular in Europe but face a substantial challenge meeting more stringent emission standards in the U.S.

Advanced multi-mode diesel engines combine homogeneous charge compression ignition operation at lower engine speeds and loads to minimize particulate matter (PM) and NO_x emissions compared to conventional diesels and revert to conventional diesel engine operation at higher speeds and loads to ensure expected power levels. In the long term, use of diesel multi-mode technology, coupled with an integrated starter generator, could allow about a 30 percent reduction in CO_2. Maximum use of homogeneous charge combustion lessens the burden of aftertreatment of NO_x and PM emissions. However, while this technology affords less emission cleanup, it does not achieve quite the low CO_2 emissions as the conventional HSDI diesel engine. Some manufacturers have recently expressed considerable optimism regarding successful development of advanced multi-mode engines that operate over a wide range of engine speeds and loads. Accordingly, there is increased optimism that such diesel engines will be able to affordably meet very low NOx and PM emission levels with a minimum of aftertreatment and still deliver significant CO_2 reductions.[51]

For the near-term, staff discussions with some manufacturers indicate they are intent on introducing light-duty diesels meeting the full complement of California requirements, including OBD, by 2009.

The following table (reproduced here from Attachment 3, item 3, p. 59) summarizes the above and other potential technologies and their greenhouse gas emission reduction potentials:[52]

[See Next Page]

[51] A summary of the interplay between gasoline engine technologies – many of which are identified above – and diesel engine technologies is provided at Attachment 3, item 25.
[52] See Appendix A hereto for a list of abbreviations applicable to this and subsequent tables.

Potential Carbon Dioxide Emissions Reductions from Individual Technologies (from NESCCAF, 2004)

	Vehicle Class				
	Small car	Large car	Minivan	Small truck	Large truck
Baseline 2002 CO_2 emissions (g/mi)	291.4	344.6	395.4	444.7	511.6
Technologies	*Percent reduction from 2002 baseline*				
Near Term Technologies 2009-2012					
Intake Cam Phasing	-2%	-1%	-1%	-1%	-2%
Exhaust Cam Phasing	-2%	-3%	-2%	-2%	-3%
Dual Cam Phasing (DCP)	-3%	-4%	-2%	-3%	-4%
Coupled Cam Phasing (CCP)	-3%	-4%	-2%	-2%	-4%
Discrete Variable Valve Lift (DVVL)	-4%	-4%	-3%	-4%	-4%
Continuous Variable Valve Lift (CVVL)	-5%	-6%	-4%	-5%	-5%
[2]Turbocharging (Turbo)	-6%	-8%	-6%	-6%	
[3]Electrically Assisted Turbocharging (EAT)	-6%	-8%	-6%	-6%	
[2]Cylinder Deactivation (DeAct)	-3%	-6%	-5%	-6%	-4%
[1]Variable Charge Motion (CBR)	-3%	-4%	-2%	-3%	-4%
[5]Variable Compression Ratio	-7%	-7%	-7%	-7%	-7%
[5]Gasoline Direct Injection - Stochiometric (GDI-S)	0%	-1%	1%	1%	0%
[2]4-Speed Automatic Transmission	0%	0%	0%	0%	0%
[2]5-Speed Automatic	-2%	-1%	-1%	-1%	-1%
[2]6-Speed Automatic	-3%	-3%	-3%	-3%	-2%
[6]6-Speed Automated Manual	-8%	-7%	-8%	-8%	-5%
[2]Continuously Variable Transmission (CVT)	-4%	-3%	-4%		
[2]Electric Power Steering (EPS)	-1%				-1%
[3]Electro-Hydraulic Power Steering (E-HPS)	-1%				-1%
[2]Improved Alternator (Higher efficiency)	-1%				0%
[2]Electric Accessories	-3%				-2%
[3]Aggressive Transmission Shift-Logic	-1.5%	-1.5%	-1.5%	-1.5%	-1.5%
[3]Early Torque Converter Lock-up	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
[2]Variable Displacement AC Compressor	-10%	-9%	-7%	-9%	
[2]Aerodynamic Drag Coefficient (% CO_2 / % Cd)	0.165				0.192
[2]Improved Tire Rolling Resistance (% CO_2 / % TRR)	0.180				0.204
Mid Term 2013-2015					
[1]Electromagnetic Camless Valve Actuation (emCVA)	-11%	-11%	-11%	-11%	-11%
[2]Electrohydraulic Camless Valve Actuation (ehCVA)	-11%	-16%	-11%	-13%	-12%
[5]Gasoline Direct Injection - Lean-Burn Stratified (GDI-L)	-6%	-9%	-4%	-5%	-8%
[5]Gasoline Homogeneous Compression Ignition (gHCCI)	-4%	-6%	-3%	-4%	-5%
[2]Electric Water Pump (EWP)	0%				0%
[2]42-Volt 10 kW ISG (Start Stop)	-7%	-4%	-4%	-4%	-5%
[2]42-Volt 10 kW ISG (Motor Assist)	-10%	-6%	-6%	-6%	-5%
[2]Diesel – HSDI	-20%	-22%	-24%	-27%	-23%
Long Term 2015-					
[6]Moderate Hybrid-Electric Vehicle (HEV)	29%	29%	29%	29%	29%
[6]Advanced Hybrid-Electric Vehicle (HEV)	54%	54%	54%	54%	54%
[2]Diesel – Advanced Multi-Mode	-13%	-15%	-18%	-21%	-17%

[1] Based on Literature Search; [2] Based on Full AVL CRUISE Simulation; [3] Based on Combined Literature/AVL CRUISE Simulation; [4] Estimated Value; [5] Additional Reduction due to Downsizing is not Included; [6] HEV numbers based on internal CARB analysis (not from NESCCAF, 2004), See Technical Support Document

Alternative Fueled Vehicles

Alternative fuel vehicles have been used for many years as a means of providing reductions of smog-forming emissions. Alternative fuel vehicles may also provide reductions of climate change pollutants, in two ways. First, during the combustion process, alternative fuels produce lower climate changes emissions. Second, alternative fuels have different upstream emissions than conventional gasoline or diesel. The upstream emissions are the "well-to-tank" emissions, and include the fuels' extraction, transport, processing, distribution, and marketing.

Listed below are estimated CO_2 emissions for current conventional vehicles and several alternative fuels. As shown in the table, each alternative fuel vehicle technology analyzed can provide positive climate change benefits relative to comparable gasoline-fueled vehicles.

Potential Carbon Dioxide Equivalent Emissions Reductions with Alternative Fuel Vehicle Technologies for Passenger Cars

Vehicle type	Vehicle CO2 emissions (g/mi)	Upstream CO2 equivalent emissions (g/mi)	Total CO2 emissions (g/mi)	Lifetime CO2 equivalent emissions (ton)	Lifetime CO2 equivalent emissions reduced from 2002 baseline (ton)	Percent reduction from Conventional Gasoline Vehicle
Conventional vehicles	346.7	102.7	449	99.9	0.0	0%
Compressed natural gas (CNG)	284.8	92.9	378	83.9	15.9	16%
Liquid petroleum gas (LPG)	313.9	50.4	364	80.9	18.9	19%
HEV20	89.0	82.0	171	38.1	61.8	62%
Ethanol (E85)	356.9	-12.7	344	76.5	23.4	23%
Electric	0	150	150	33.4	66.5	67%

Improved Air Conditioning Systems

Mobile air conditioning contributes to GHG emissions through "direct" refrigerant releases and "indirect" exhaust CO_2 emissions. Direct emissions include releases from vehicles through air conditioning system leakage that can be cost-effectively reduced by up to 50 percent through system improvements such as the use of low-permeability hoses and improved elastomer seals and connections. Direct emissions could also be virtually or completely eliminated by switching from the current industry standard HFC-134a to alternative refrigerants HFC-152a (1,1-difluoroethane) or to CO_2. HFC-152a could be introduced as a vehicular refrigerant on a schedule that appears to be consistent with the requirements of AB 1493.

Although current emission certification testing procedures do not include operation of vehicle air conditioning systems, their operation contributes significantly to exhaust CO_2 emissions, also known as "indirect emissions." These emissions are largely due to the added load on the engine from operating the air conditioning system. It has been estimated that CO_2 emission reductions from 30 to 50 percent of the fraction of total vehicular greenhouse gas emissions attributable to air conditioning use may be achievable by reducing the engine load requirements of air conditioning systems. Potential measures for reducing indirect emissions include more efficient variable displacement compressors (VDC) with better control systems – currently available and used in European vehicles – and condensers and evaporators with improved heat transfer. Other measures include reducing the amount of outside air admitted to the passenger compartment relative to recirculated air, indirect emission gains from substituting with HFC-152a, and reducing vehicles' solar load.

Applying a low-leak system or changing refrigerants, and applying improvements for reducing indirect emissions across a manufacturer's conventional gasoline vehicle fleet, can provide nearly all of the greenhouse gas reductions needed to meet both the PC/LDT1 and LDT2/MDPV fleet average greenhouse gas emission standards through the 2010 model year, and about 20% of the required reductions for the 2011-2014 model years. In addition, reductions from both direct and indirect air conditioner emission technologies can be applied to alternative fuel vehicles, thus increasing those vehicles' GHG reduction benefits.

b. Combined Technologies

Given the multitude of technologies available for reducing vehicle CO_2 emissions, CARB needed to apply engineering guidelines for choosing combinations that would be economical to the consumer. Generally it is important to avoid combining technologies that tend to address the same categories of losses or technologies that may not complement each other from a drivability standpoint. On the other hand, some technologies are attractive to combine because their features enhance each other.

After projecting likely technology combinations, CARB determined advanced simulation modeling was needed to consider the combined greenhouse gas reduction potential of combined technologies and to avoid double-counting benefits from simply adding up reductions from individual technologies. AVL, with worldwide recognition as one of the premier experts in vehicle technology simulations and with unparalleled access to individual engine maps, performed this modeling under contract to the Northeast States Center for a Clean Air Future (NESCCAF). AVL applied its proven CRUISE simulation model to arrive at the greenhouse gas emission reduction estimates for the combinations of advanced technologies ultimately used by CARB staff in generating the Greenhouse Gas Emission Standards.

Potential technology packages, by vehicle class, are provided in Attachment 3, item 5, and related discussions are in Attachment 3, item 3. Some of the technology packages manufacturers are more likely to apply for the near-term standards beginning in the 2009 model year (fully phased in by 2012) and their associated greenhouse gas emissions reductions are:

Maximum Feasible Near-Term CO_2 Reduction Levels

Vehicle Class	Combined Technology Packages	Test CO_2 equivalent with A/C credit (g/mi)	Percent CO_2 Reduction	CO_2-equivalent Emission Standard (g/mi)
Small car	Discrete Varaiable Valve Lift, Dual Coupled Cam Phasing, Autometed Manual Transmission, Electric Power Steering, Improved Alternator	219	18.0	233
	Gasoline Direct Injection Stoichiometric, Dual Cam Phaser, Turbo, Automated Manual Transmission, Electric Power Steering, Improved Alternator	200	24.6	
Large car	Gasoline Direct Injection Stoichiometric, Cylinder Deactivation, Dual Cam Phaser, Automated Manual Transmission, Electric Power Steering, Improved Alternator	248	18.0	
	Gasoline Direct Injection Stoichiometric, Dual Cam Phaser, Turbo, Automated Manual Transmission, Electric Power Steering, Improved Alternator	234	22.3	
Minivan	Continuous Variable Valve Lift, Coupled Cam Phaser, Automated Manual Transmission, Electric Power Steering, Improved Alternator	287	17.6	361
	Gasoline Direct Injection Stoichiometric, Dual Cam Phaser, Turbo, Automated Manual Transmission, Electric Power Steering, Improved Alternator	279	19.9	
Small truck	Cylinder Deactivation, Discrete Variable Valve Lift, Coupled Cam Phaser, Automated Manual Transmission, Electric Power Steering, Improved Alternator	308	19.1	
	Gasoline Direct Injection Stoichiometric, Dual Cam Phaser, Turbo, Automated Manual Transmission, Electric Power Steering, Improved Alternator	298	21.5	
Large truck	Cylinder Deactivation, Discrete Variable Valve Lift, Coupled Cam Phaser, Automatic 6-Speed Transmission, Electro-hydraulic Power Steering, Improved Alternator	398	13.8	
	Cylinder Deactivation, Discrete Variable Valve Lift, Coupled Cam Phaser, Automated Manual Transmission, Electro-hydraulic Power Steering, Improved Alternator	376	18.3	

The far right column indicates the fully phased-in (2012) PC/LDT1 and LDT2/MDPV standards of 233 and 361 grams per mile of CO_2-equivalent emission reductions, respectively. These standards assume that a portion of the emission reductions will be achieved through air conditioning improvements.

The mid-term standards rely primarily on refinements to and addition of some of the above technologies and additional electrical system improvements. Some of the technology packages manufacturers are more likely to apply for the mid-term standards beginning in the 2013 model year (fully phased in by 2016) and their associated greenhouse gas emissions reductions are:

[See Next Page]

Maximum Feasible Mid-Term CO_2 Reduction Levels

Vehicle Class	Combined Technology Packages	Test CO_2 equivalent with A/C credit (g/mi)	Percent CO_2 Reduction from 2009 Baseline	CO_2-equivalent Emission Standard (g/mi)
Small car	Continuous Variable Valve Lift, Dual Cam Phaser, Automated Manual Transmission, Integrated Starter Generator-Start/Stop, Electric Power Steering, Improved Alternator	196	24.0	205
	Gasoline Homogeneous Compression Ignition, Discrete Variable Valve Lift, Intake Cam Phasing, Automated Manual Transmission, Integrated Starter Generator, Electric Power Steering, Electric Accessories	184	28.3	
Large car	Electro-hydraulic Camless Valve Actuation, Gasoline Direct Injection Stoichiometric, Automated Manual Transmission, Electric Power Steering, Improved Alternator	220	25.1	
	Gasoline Homogeneous Compression Ignition, Discrete Variable Valve Lift, Intake Cam Phasing, Automated Manual Transmission, Integrated Starter Generator, Electric Power Steering, Electric Accessories	209	28.4	
	Gasoline Direct Injection Stoichiometric, Turbo, Dual Cam Phaser, Automatic 6-Speed Transmission, Integrated Starter Generator, Electric Power Steering, Electric Accessories	202	30.7	
Minivan	Electro-hydraulic Camless Valve Actuation, Gasoline Direct Injection Stoichiometric, Automated Manual Transmission, Electric Power Steering, Improved Alternator	266	21.8	332
	Gasoline Direct Injection Stoichiometric, Coupled Cam Phaser, Automated Manual Transmission, Integrated Starter Generator, Cylinder Deactivation, Electric Power Steering, Electric Accessories	263	22.7	
Small truck	Cylinder Deactivation, Discrete Variable Valve Lift,Coupled Cam Phaser, Automatic 6-Speed Transmission, Integrated Starter Generator, Electric Power Steering, Electric Accessories	290	22.1	
	Electro-hydraulic Camless Valve Actuation, Gasoline Direct Injection Stoichiometric, Automated Manual Transmission, Electric Power Steering, Improved Alternator	283	23.8	
	High Speed Direct Injection Diesel, Automated Manual Transmission, Electric Power Steering, Improved Alternator	280	22.1	
Large truck	Electro-hydraulic Camless Valve Actuation, Gasoline Direct Injection Stoichiometric, Automated Manual Transmission, Electro-hydraulic Power Steering, Improved Alternator	355	21.3	
	Cylinder Deactivation, Discrete Variable Valve Lift, Coupled Cam Phaser, Automatic 6-Speed Transmission, Integrated Starter Generator, Electric Power Steering, Electric Accessories	352	22.1	

Again, the far right column above indicates the fully phased-in (2016) PC/LDT1 and LDT2/MDPV standards of 205 and 332 grams per mile of CO_2-equivalent emission reductions, respectively. And again, these standards assume that a portion of the emission reductions will be achieved through air conditioning improvements.

Manufacturer Concerns

Once the manufacturers chose to engage in a limited way in the Greenhouse Gas Rulemaking, they raised numerous arguments concerning the feasibility of both the individual technologies and the combinations of them projected in the two previous tables. These comments are exhaustively addressed in Attachment 3, item 12, e.g. at pp. 105-141. Some of their overarching arguments are addressed here.

First, a manufacturer commented that CARB overestimated emission reductions from powertrain changes assumed in many of the technology packages, and that changes of the magnitude projected cannot be applied to the American fleet because all U.S. driveline plants would need to be retooled, maybe more than once. However, CARB responded that U.S. manufacturers are already planning to incorporate improved transmissions on their vehicles in the near future and have the capacity, for example, to produce 6-speed automatic transmissions either in-house or to purchase them from willing suppliers. Furthermore, since the emission standards begin modestly in 2009 and ramp up over an eight year period, manufacturers are provided substantial lead time to phase-in new technologies across their vehicle fleets consistent with scheduled vehicle upgrades, thus minimizing additional retooling costs.

Second, a manufacturer commented that aggressively downsized, highly turbocharged, intercooled, direct-injected engines with dual cam phasing were used to set the standard in all but one of the vehicle segments, and that such engines will require more expensive premium fuel and will not meet consumer expectations. CARB responded in part that AVL's modeling was based on actual engine data and maps AVL developed therefrom, and that AVL has provided assurances that the GHG emission reductions and performance modeled for turbocharged applications in conjunction with direct-injection engines was achievable with regular fuel. CARB also noted that manufacturers either have or are developing world class engines that incorporate cam phasing and that are fully compatible with turbocharging and direct injection with no additional refinements or modification needed.

Manufacturers also commented that combining technologies risks double-counting, yet that is precisely why CARB relied on results generated by AVL and NESCCAF. Unlike the manufacturers' consultant, whose less sophisticated modeling does indeed present the double-counting issue, AVL's CRUISE model in conjunction with real engine maps for the various combinations of technologies that few manufacturers have access to, is the best estimating approach available – and one that manufacturers themselves find compelled to rely upon – to estimate how technologies will combine in projecting a real vehicle's performance and emissions.

c. Lead Time

As noted repeatedly throughout the rulemaking documents, the Greenhouse Gas Regulations rely less on traditional "technology-forcing" than on repackaging a combination of "off-the-shelf" technologies to meet the adopted standards. With few exceptions, lead-time to develop these individual technologies is simply not an issue. The issue is whether they can be combined in time across manufacturer fleets to meet the standards. Again, there is abundant evidence in the record showing that they can.

Regarding the onset of the standards in model year 2009, manufacturers objected to CARB estimates of a 36-month lead-time as unrealistic, stating that many of the technologies the CARB staff relies upon involve fundamental changes to both engines and transmissions. They commented that the lead-time for the development, tooling, production, and validation of the required new engines and transmissions will take far longer than 36 months, probably closer to 60 months, and that direct OEM investment must begin immediately. In response, CARB noted that GM has provided an example of how manufacturers are already designing engines to incorporate many of the new technologies outlined by staff as being capable of meeting the proposed requirements. This is particularly true for those technologies that would be utilized in the near-term (e.g., more sophisticated valve trains, turbocharging, direct injection, etc.). GM and Ford already have newly designed 6 speed automatic transmissions in the pipeline (which CARB indicated would achieve all the emission benefits ascribed to the AMT transmission in the study). Manufacturers are thus already poised to implement the technologies even before the operative 2009 date of the regulation. In addition, given the manufacturers' ability to meet early year requirements almost exclusively through air conditioning improvements,[53] 2011 may be a more appropriate starting point for assessing lead time.

Regarding the 2012 and 2016 compliance points for the standards, a manufacturer commented that CARB went considerably beyond National Research Council (NRC) guidelines for industry lead-times by requiring full penetration of certain technologies for the near-term standards within eight years and also full penetration of emerging, "mid-term" technologies in the following four years. The commenter stated that it is unrealistic for CARB to rely heavily on technologies such as camless valve actuation in this time frame, since these mid-term technologies are still in the research and

[53] See end of Section V.C.1.a.

development stage and described by the NRC as requiring "considerably" longer lead times.

Despite the commenter's stated concerns about camless valve actuators, CARB has found that reductions in greenhouse gas emissions are being pursued aggressively in Europe and Japan and other regions of the world as a result of government agreements and regulations affecting the vehicle manufacturers in these countries. The research indicates that greenhouse gas reductions should occur in these regions sooner than what is being required in the CARB regulations. Based on input staff has received from companies producing vehicles in those countries, California's lead-time is fully consistent with manufacturer product plans for bringing these technologies to market worldwide. Meanwhile, increasingly the competitiveness of a company depends on being able to bring new designs to market quickly in response to consumer trends. This reduction in lead-time is an ongoing reality in today's market. Also, the comment was remarkable in that it acknowledged the regulation's generous lead-times of eight and twelve years for the fully phased-in 2012 and 2016 standards, respectively, which are well in excess of any conceivable reading of *NRDC* or *International Harvester*.[54]

CARB also considered manufacturer arguments concerning rate of return and existing product plans, even though such arguments are not directly relevant to whether they can slightly change course to meet the Greenhouse Gas Emission Standards. Given the pace of new technology introductions and replacement laid out by CARB in its technical justification, one manufacturer questioned whether maturation of technologies to "fully learned" levels might ever occur. They stated that the expected rate of change is simply too fast and disruptive, and expected product lifetimes too short, with new technology packages forced across the fleet in four year waves moving from the near-term technologies in 2009-2012, to mid-term technologies in 2013-2016 to, presumably, long-term technologies described in the CARB technical analysis in 2017. They further stated that the shortened product lifecycles implied by this progression are not consistent with normal cost levels or rates of return, where powertrain technologies such as new engines or transmissions need useful economic lives of 10-20 years to be economically justifiable.

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[54] *NRDC* upheld a particulate matter standard EPA finalized in 1980 for the 1985 model year, which could have started as early as 3 ½ years later. 655 F.3d. at 323. Following supplemental briefing, *International Harvester* considered a lead time of just over a year. 478 F.2d at 627-28. Since the numerical limits approved by the Board in September, 2004 did not change through OAL approval in September, 2005, here affected manufacturers arguably had eight and 12 years of lead time, respectively. Even if EPA chooses to focus on the onset of the near-term standard phase-in beginning in model year 2009 – still with over 2 ½ to 3 ½ years to the earliest potential production for that model year – EPA must give substantial deference to CARB's evaluation of lead time for each year through the phase-in. See 61 Fed.Reg. 53371 (October 11, 1996) (*OBD II*), Decision Document at pp. 71-74.

CARB never envisioned that manufacturers would build a set of technologies for four years and then discard them for another new set of technologies for the next four years. Rather, CARB expects that a manufacturer would plan for a rollout of new technologies that would begin in 2009 and then build on the initial efforts with additional near- and mid-term technologies that would be commensurate with previous investments. These technologies were presumed to continue to be utilized beyond 2016 and would provide for amortization of costs. For example, a manufacturer might begin to introduce downsized turbocharged direct injected engines in the near term and build on them by adding integrated starter generators and additional electrical accessories and improved air conditioning systems for the mid term. The commenter (GM) should now understand this progression, since in describing its new 3.6 liter V6 engine, they indicated those engines are already designed to be compatible with both turbocharging and direct injection technologies with no additional redesign or strengthening needed.[55]

d. Consideration of Costs

For projected technology costs the CARB relied on cost estimates from the Martec group for components needed for vehicles that could meet our requirements and further relied on a markup factor determined by Argonne National Laboratory (ANL) to arrive at a retail price increase once component costs to the manufacturer were known. Martec is a consulting firm with extensive experience in forecasting the emergence of new technologies and projecting their costs, based on their interviews with parts suppliers and vehicle manufacturers. Staff has compared notes with Martec informally for more than a decade in projecting costs for the LEV program and has established a long-standing confidence in their knowledge and reliability in assessing component and system costs within the automobile industry.

The average cost of control for maximum feasible climate change emission reductions for near-term technology packages on a vehicle in the PC/LDT1 category is estimated to be $383. The average cost of control for maximum feasible reductions for near-term technology packages on a vehicle in the LDT2/MDPV category is estimated to be $327. These costs do not include any operating cost savings, which staff has determined to be more than sufficient to offset upfront incremental costs, thus resulting in a net savings to the purchaser:

[See Next Page]

[55] Attachment 3, item 21, Declaration of Steve Albu, para. 22.

Technology Cost for Maximum Feasible Near-Term CO_2 Reduction by Vehicle Category

Vehicle Class	Combined Technology Packages	Cost incremental from 2009 baseline (2004$)	Average cost incremental from 2009 baseline (2004$)	Estimated percentage of CA 2002 fleet	Average cost for near-term control technology for vehicle category ($)
Small car	DVVL,DCP, AMT,EPS,ImpAlt	*148*	*480*	34%	*383*
	GDI-S,DCP,Turbo, AMT,EPS,ImpAlt	812			
Large car	GDI-S,DeAct,DCP, AMT,EPS,ImpAlt	504	*224*	20%	
	GDI-S,DCP,Turbo, AMT,EPS,ImpAlt	*-57*			
Minivan	CVVL,CCP,AMT, EPS,ImpAlt	696	*471*	9%	*327*
	GDI-S,DCP,Turbo, AMT,EPS,ImpAlt	*246*			
Small truck	DeAct,DVVL,CCP, AMT,EPS,ImpAlt	*245*	84	22%	
	GDI-S,DCP,Turbo, AMT,EPS,ImpAlt	-77			
Large truck	DeAct,DVVL,CCP, A6,EHPS,ImpAlt	663	607	15%	
	DeAct,DVVL,CCP, AMT,EHPS,ImpAlt	551			

Similar calculations were performed for the maximum feasible emission reductions for mid-term technology packages. The average cost of control to achieve the maximum feasible reduction for a vehicle in the PC/LDT1 category is estimated to be $1,115. The average cost of control to achieve the maximum feasible reduction for vehicles in the LDT2/MDPV category is estimated to be $1,341. Again, these costs do not include operating cost savings:

[See Next Page]

Technology Package Cost for Maximum Feasible Mid-Term CO_2 Reduction by Vehicle Category

Vehicle Class	Combined Technology Packages	Cost incremental from 2009 baseline (2004$)	Average cost incremental from 2009 baseline (2004$)	Estimated percentage of CA 2002 fleet	Average cost for mid-term control technology for vehicle category ($)
Small car	CVVL,DCP,AMT, ISG-SS,EPS,ImpAlt	714	1,087	34%	1,115
	gHCCI,DVVL,ICP, AMT,ISG,EPS,eACC	1459			
Large car	CVAeh,GDI-S, AMT,EPS,ImpAlt	762	1,162	20%	
	gHCCI,DVVL,ICP, AMT,ISG,EPS,eACC	1575			
	GDI-S,Turbo,DCP, A6,ISG,EPS,eACC	1149			
Minivan	CVAeh,GDI-S, AMT,EPS,ImpAlt	1099	1,345	9%	1,341
	GDI-S,CCP,AMT,ISG, DeAct,EPS,eACC	1590			
Small truck	DeAct,DVVL,CCP, A6,ISG,EPS,eACC	1471	1,118	22%	
	CVAeh,GDI-S, AMT,EPS,ImpAlt	742			
	HSDI,AMT, EPS,ImpAlt	1141			
Large truck	CVAeh,GDI-S, AMT,EHPS,ImpAlt	1583	1,672	15%	
	DeAct,DVVL,CCP, A6,ISG,EPS,eACC	1760			

Multiplying the cost-of-control estimates by the corresponding percentages of each manufacturer's fleet that will need to use these packages to achieve compliance, results in the average cost increase per vehicle manufacturer per model year to meet the Greenhouse Gas Regulations. These average costs per vehicle for each manufacturer for each model year are shown in the following table. The final column "All major 6" shows the estimated cost increase averaged across all vehicle sales of the six manufacturers.

Average Cost of Control by Manufacturer and Vehicle Model Year ($)

Year			DC	Ford	GM	Honda	Nissan	Toyota	All major 6
2009	Near-term phase-in	PC/LDT1	77	41	0	0	0	0	17
		LDT2/MDPV	59	19	65	0	20	0	36
2010		PC/LDT1	153	132	76	0	21	3	58
		LDT2/MDPV	118	85	131	0	67	8	85
2011		PC/LDT1	268	268	230	94	189	192	230
		LDT2/MDPV	206	183	229	0	138	106	176
2012		PC/LDT1	383	383	383	311	358	381	367
		LDT2/MDPV	294	306	327	105	210	203	277
2013	Mid-term phase-in	PC/LDT1	530	530	530	454	396	520	504
		LDT2/MDPV	512	519	530	139	224	222	434
2014		PC/LDT1	676	676	676	386	553	667	609
		LDT2/MDPV	701	713	733	172	238	241	581
2015		PC/LDT1	895	895	895	637	789	888	836
		LDT2/MDPV	991	1008	1037	222	259	270	804
2016		PC/LDT1	1115	1115	1115	896	1024	1108	1064
		LDT2/MDPV	1288	1308	1341	272	279	298	1029

Regarding these costs, again manufacturers have raised numerous arguments that CARB exhaustively addressed in Attachment 3, item 12, e.g. at pp. 141-189, 394-406. Again, some of their overarching arguments are addressed here.

Manufacturer Concerns

Manufacturers commented that CARB underestimated costs of individual technologies because CARB did not use manufacturers' costs to independently develop each of these technologies, including extensive tear-down of existing facilities. But this would result in the same kind of inappropriate double-counting of costs that CARB avoided in its emission reduction calculations. To avoid that result again here, CARB used a 1.4 retail price equivalent mark-up factor developed by Argonne National Laboratories.[56] Given that suppliers can quote prices now for most parts likely to be needed to meet the proposed regulations, this factor assumes most will be obtained so, and accounts for manufacturers' costs to integrate those supplier-provided parts. (Of course, this does

[56] Interestingly, this same mark-up factor appears to be assumed in a recent NHTSA-proposed rulemaking in which NHTSA reviewed some of the same technologies that CARB reviewed here. See page p. VI-8 of the preliminary regulatory impact analysis (PRIA) mentioned in 70 Fed.Reg. 51414 (August 30, 2005). The NAS study – which NHTSA relies on extensively in the PRIA – states, "Cost estimates provided by component manufacturers were multiplied by a factor of 1.4 to approximate the retail price equivalent (RPE) costs for vehicle manufacturers to account for other systems integration, overhead, marketing, profit, and warranty issues (EEA, 2001)" and "…since many of the cost figures were supplied by component and subsystem suppliers, a factor of 1.4 was applied to the supplied cost to arrive at the RPE to the consumer." Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards (2002), National Academy Press, p. 41.

not preclude manufacturers from building or retooling at least some of their own facilities to generate a lower unit cost than that of a supplier.) In addition, CARB assumed a further 30% discount for a limited number of components where unanticipated improvements in production processes or simplifications or consolidation in parts after additional further development would be likely. CARB experience with new technologies is that their costs continue to improve beyond our expectations based on early estimates as demonstrated in the Low-Emission Vehicle program, and as assumed in the federal Tier II program.[57]

As a net result of this difference in assumed mark-up and the previously described differences in assumed feasible technologies, the manufacturers and CARB arrived at widely differing costs for compliant vehicles. As stated, CARB estimates costs to be about $1000 per fleet vehicle for the fully-phased in mid-term (2016) standards; manufacturers, on the other hand, argue that costs will be a few times that. As fully detailed in the rulemaking (Attachment 3, item 12) there is abundant support in the record for CARB's conclusions, and manufacturers will simply not be able to meet their burden of proof under the waiver analysis to overcome CARB's conclusion that the technologies are feasible given consideration to the costs in the time provided for compliance.

The Sierra Research study commissioned by the Alliance of Automobile Manufacturers ("manufacturer study" or "study" hereinafter) found that on average vehicle costs would increase by about $3000. However, as summarized here and in one response to comment (Attachment 3, item 12, comment and response #254),[58] the manufacturer study rejected promising and cost-effective emerging engine technologies as elements of a greenhouse gas regulatory compliance strategy. Even though companies such as General Motors have revealed publicly that they are designing core engines for compatibility with such technologies as turbochargers and gasoline direct injection systems, the manufacturer study rejects both as of little value in reducing greenhouse gas emissions. They also did not consider homogeneous charge compression ignition (HCCI) engines or camless valve actuation systems that provide substantial, cost-effective greenhouse gas reductions.

It also appears that the manufacturer study did not have the necessary engine maps for advanced engine technologies to properly quantify their benefits. For example, all of the turbocharging applications selected by CARB are combined with a gasoline direct injection engine (GDI-S). This combination was chosen precisely because GDI engines

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[57] See U.S. EPA Tier 2 Regulatory Impact Analysis, December, 1999, Section A.1.a, (pp. V-1, V-2, and V-4), and Section A.1.f. (p. V-25). "As shown in Table V-11, we project manufacturer costs to decrease by 21 to 40 percent for the long-term." *Id*.

[58] For a summary of the differences in analytical approach between CARB and manufacturers, see Declaration of Steve Albu, Attachment 3, item 21.

can operate at higher compression ratios than conventional gasoline engines while still using regular fuel, thereby allowing the full benefits of engine downsizing to be realized. The manufacturer study noted that it did not have access to engine maps for GDI-S engines and, therefore, dismissed the benefits afforded by this combination of technologies out of hand. The study thus rejected the near-certainty of reasonable innovation by industry in response to regulatory requirements.

Instead, the manufacturer study resorted to modeling extremely expensive weight reduction measures such as aluminum body structures employed by very expensive sport luxury cars such as the Audi A8 or Jaguar XJ8. This step alone resulted in a cost increase of more than $2000 per car. Use of aluminum in high volume vehicle lines is not credible.[59]

In addition, the manufacturer study estimates of some technology costs were not reasonable. For example, the study indicated a cost estimate for continuously variable valve timing and lift technology based on BMW's Valvetronic system ($808), even though the authors were aware of a simpler, less costly design approach that was outlined in the CARB staff analysis ($581). The study indicated a 6 speed automatic transmission would cost $624, versus CARB's estimate of $105 compared to a 4 speed automatic. Given that GM and Ford are jointly developing a 6 speed automatic transmission that will be used widely across their product line before 2009, it is assumed that they will be able to manufacture the product cheaper than estimated in the manufacturer study. It is also assumed that if other manufacturers are not able to design their own new technology, they will turn to suppliers who can develop advanced products comparable to the systems manufactured by GM and Ford.

The manufacturer study also estimated that cylinder deactivation would cost $456 per vehicle vs. $105 estimated by CARB staff. Although the study generally accepted the base system hardware cost estimate used by CARB, it added an exorbitant cost for noise, vibration, and harshness (NVH) control that accompanies the feature. It appears the study may have relied on a production prototype developed by GM, which included an expensive stainless steel control valve in the exhaust. CARB noted that GM's actual production system, after more than a year delay in introduction, appears to mimic the simpler, much less costly NVH control system used for the Chrysler 300C instead. CARB's cost estimate was based on the latter system, which provides the basis for a more credible cost estimate.

Again, the manufacturer study also double counted for supplier investments in designing and building their products. Even though Martec made it clear that their cost

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[59] Exorbitant costs aside, CARB staff did not take a weight reduction approach, both because AB 1493 prohibited it, and to ensure full model availability.

estimates were for components engineered and produced by a supplier, the manufacturer study used a markup factor in their estimates that should only be used if a part is designed and produced in house by the manufacturer. The study ended up double counting for manufacturers' own costs and the costs of supplier research and development, investment in plants and tooling to produce the products, and associated warranty coverage.

In conclusion, CARB staff believes that the principle cost analysis manufacturers relied upon greatly overstated the costs of the Greenhouse Gas Regulations. It is apparent that they used faulty technical analysis and inflated component costs. It and evidence like it leave manufacturers far from meeting their burden established under the waiver process to demonstrate that the regulations are not technically feasible. They fail to refute CARB's feasibility findings, including cost considerations. The record accordingly strongly supports CARB's technical feasibility conclusions. The ongoing rollout of more and more vehicles with precisely the projected technologies and combinations of many of them that could meet the Greenhouse Gas Emission Standards – four years ahead of the first model year affected and nine years ahead of the first compliance deadline – makes the manufacturers burden to prove otherwise even more difficult, if not impossible.

2. CONSISTENCY OF TEST PROCEDURES

Because there are no federal test procedures that measure greenhouse gases for climate change purposes, there are no potential inconsistencies precluding a manufacturer from using the same test vehicle to meet both federal and California requirements. In addition, CARB notes that the test procedures incorporated by reference may allow a manufacturer to apply the results of certain test vehicles to meet other federal requirements, such as those in 40 CFR Part 600. CARB and U.S. EPA presently share data from 40 CFR Part 600 testing as part of the LEV II program. See e.g. 13 CCR §1961(a)(6) and related waiver at 68 FR 19811 (April 22, 2003). Here, manufacturers could also use that same test vehicle to apply 40 CFR Part 600 results in the broader context of U.S. EPA's requirement to calculate total greenhouse gas emissions, which includes calculating emissions and reductions from other greenhouse gas sources, e.g. from air conditioning credits. However, because CARB's regulations apply to different vehicle classes than those tested under 40 CFR Part 600, manufacturers would need to test additional vehicles to demonstrate compliance with California's fleet average greenhouse gas standards.

To conclude the consistency discussion, then, neither of the only two considerations U.S. EPA may consider in reviewing consistency with section 202(a) apply here. There is adequate lead-time giving appropriate consideration to costs, and there are no inconsistent test procedures. Thus, there is no basis for the Administrator to deny California's waiver request for inconsistency with CAA section 202(a).

IX. CONCLUSION

Based on the foregoing, U.S. EPA must waive federal preemption of California's Greenhouse Gas Emission Standards and related amendments to California's test procedures for engines to demonstrate compliance with those standards. As referenced throughout the foregoing discussion, Attachment 3, provided in hard copy and compact disc, contains documents pertaining to the Greenhouse Gas Regulations and accompanying test procedures covered in this Support Document.

APPENDIX A

LIST OF ACRONYMS AND ABBREVIATIONS

A4:	4-speed automatic transmission
A5:	5-speed automatic transmission
A6:	6-speed automatic transmission
AB 1493:	Assembly Bill 1493
AdvHEV:	Advanced hybrid
CARB:	California Air Resources Board
AMT:	Automated Manual Transmission
CCP:	Coupled cam phasing
CH_4:	Methane
CNG:	Compressed natural gas
CO_2:	Carbon dioxide
CVVL:	Continuous variable valve lift
CVT:	Continuously variable transmission
DCP:	Dual cam phasing
DeAct:	Cylinder deactivation
dHCCI	Diesel homogeneous charge compression ignition
DMV:	California Department of Motor Vehicles
DOHC:	Dual overhead cam
DVVL:	Discrete variable valve lift
DVVLd:	Discrete variable valve lift, includes dual cam phasing
DVVLi:	Discrete variable valve lift, includes intake valve cam phasing
eACC:	Improved electric accessories
EAT:	Electronically assisted turbocharging
EGR:	Exhaust gas recirculation
ehCVA:	Electrohydraulic camless valve actuation
emCVA:	Electromagnetic camless valve actuation
EHPS:	Electrohydraulic power steering
EPS:	Electric power steering
EMFAC:	CARB Emission Factors model (EMFAC2002 v.2.2 April 23, 2003)
EWP:	Electric water pump
FDC:	Fixed displacement compressor
FWD:	Front-wheel drive
GDI-S:	Stoichiometric gasoline direct injection
GDI-L:	Lean-burn gasoline direct injection
gHCCI	Gasoline homogeneous charge compression ignition
GVWR:	Gross vehicle weight rating
GWP:	Global warming potential

HC:	Hydrocarbons
HEV:	Hybrid-electric vehicle
HEV20:	An HEV with an all-electric range of at least 20 miles
HFC:	Hydrofluorocarbon
hp:	Horsepower
HSDI:	High-speed (diesel) direct injection
ICP:	Intake cam phaser
ImpAlt.	Improved efficiency alternator
ISG:	Integrated starter-generator system
ISG-SS:	Integrated starter-generator system with start-stop operation
L4:	In-line four-cylinder
MAC:	Mobile Air Conditioning
ModHEV:	Moderate hybrid
NMOG:	Non-methane organic gas
N_2O:	Nitrous oxide
NO_x:	Oxides of nitrogen
R-134a:	Refrigerant 134a, tetrafluoroethane ($C_2H_2F_4$)
R-152a:	Refrigerant 152a, difluoroethane ($C_2H_4F_2$)
RPE:	Retail price equivalent
TRR:	Tire rolling resistance
Turbo:	Turbocharging
V6:	Vee-formation six-cylinder
V8:	Vee-formation eight-cylinder
VDC:	Variable displacement compressor
4WD:	Four-wheel-drive
42V ISG:	42-volt integrated starter-generator system