Appendix 7a: National Baseline Sensitivity Analysis

7a.1 Synopsis

Circular A-4 of the Office of Management and Budget's (OMB) guidance under Executive Order 12866 defines a no-action baseline as "what the world will be like if the proposed rule is not adopted." The illustrative analysis in this RIA assesses the costs and benefits of moving from this "no-action" baseline to a suite of possible new standards. Circular A-4 states that the choice of an appropriate baseline may require consideration of a wide range of potential factors, including:

- evolution of the market,
- changes in external factors affecting expected benefits and costs,
- changes in regulations promulgated by the agency or other government entities, and
- the degree of compliance by regulated entities with other regulations. (OMB 2003)

Circular A-4 also recommends that…

> When more than one baseline is reasonable and the choice of baseline will significantly affect estimated benefits and costs, you should consider measuring benefits and costs against alternative baselines. In doing so you can analyze the effects on benefits and costs of making different assumptions about other agencies' regulations, or the degree of compliance with your own existing rules. (OMB, 2003)

This sensitivity analysis is intended to provide information about how the no-action baseline would differ under different assumptions about mobile technologies. It also assesses nationally what the change would be to costs and benefits of a new standard of 0.075 ppm and alternate primary standards of 0.079, 0.070, and 0.065 ppm. Cost for all standards would increase by $1.8 billion[1] and benefits for all standards would increase by

[1] This cost could be offset in states that choose to replace existing periodic physical inspection of vehicles with remote onboard diagnostic device inspection in Inspection and Maintenance programs. As explained in the Appendix to Chapter 3, Remote On Board Diagnostics (OBD) eliminates the need for periodic inspections of OBD-equipped vehicles by car owners. EPA estimates that the nationwide installation of Remote OBD would save the nation's motorists about $16 to $22 billion in inspection and convenience costs over a 10 year period. Refer to the Appendix 5a for more details on the cost savings of remote OBD.

\$360 million to \$3.1 billion using 2006\$ and a 3% discount rate, and \$330 million to \$2.8 billion when using a 7% discount rate.[2]

The process of analysis of costs and benefits of attaining 0.075 and the alternate primary standard is, in some ways, an incremental building exercise. EPA begins with a Base Case (that includes promulgated rules, consent decrees, existing promulgated programs) and layers onto that illustrative control strategies from previous NAAQS RIA analyses, and finally, a simulated control strategy for attaining the current NAAQS in question (O3 at 0.084 ppm). This is the point at which the "no-action baseline" is established.

Once the no-action baseline is established, EPA begins assessing the costs and benefits of moving to a tighter standard. EPA does not assess the costs and benefits of reaching the no-action baseline. Decisions about what is in the baseline affect the starting point of the assessment of costs and benefits, and thus affect the total incremental cost and benefit estimates.

The primary analysis baseline included some mobile controls characterized as additional technology changes in the onroad transportation sector. The application of these controls to the baseline assumes an optimistic future where reductions in emissions are achieved through the implementation nationally of cutting-edge mobile technologies. This sensitivity analysis estimates nationally how the costs and benefits of attaining 0.075 and the alternate primary standards would change if these technology changes were not implemented to meet the current standard, but were instead implemented as part of the strategy for attaining a new tighter standard.

In this sensitivity analysis scenario, 169,000 tons of NOx would not be reduced prior to the benefit/cost analysis. The alternate baseline or starting point for assessing the costs and benefits of the standard of 0.075 and the alternate primary standards would be higher across the board. Benefits from improved ozone and co-controlled PM2.5 air quality would increase. The costs of control would increase, as well. The air quality improvements would be accomplished by including additional onroad transportation control measures in the control scenario, equivalent to the reductions 'removed' from the alternate baseline. The value in benefits of those improvements is estimated on a \$/ton emissions reduced basis derived from the Locomotive Marine Diesel Rule.

A description of the control measures added to the alternate control scenario for this sensitivity analysis follows.

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[2] These estimates are highly uncertain and are purely illustrative estimates of the potential costs and benefits of these mobile control strategies. We present them only as screening-level estimates to provide a bounding estimate of the costs and benefits of including these emissions controls in the ozone NAAQS control case for all standards. As such, it would be inappropriate to apply these benefit per-ton estimates to other policy contexts, including other regulatory impact analyses. Furthermore, the benefits only reflect a partial accounting of the total benefits associated with emission reductions related to the mobile controls included in this sensitivity analysis.

7a.2 Control Details

7a.2.1 Improved Catalyst Design

Improved Catalyst Design is a nationwide strategy that results in tailpipe emission reductions for new vehicles. The principle technologies used to achieve the Improved Catalyst Design standards are improved catalysts and increased use of electronically controlled air injection, reducing NOx and VOC emissions for new light duty gasoline vehicles.

We modeled a program that would achieve Bin 2[3] emission levels (see Table 7a.1) for a program starting in 2013 and fully phased in by 2015.

Phase-in Scenario	Cars:	50% in 2013 100% in 2014	Trucks:	100% in 2015

Table 7a.1: Emission Standards

	NOx	NMOG
Bin 2	0.02	0.01
Bin 5 (reference)	0.07	0.09

Table 7a.2: Nationwide 2020 Tailpipe Emission Reductions (tons(%))

	2020 NOx	2020 HC
Bin 2	87,705 (7%)	93,676 (6%)

In comparison, Tier 2 reduced NOx by about 2.2 million tons in 2020 and nearly 3 million tons in 2030, a 74% reduction.

The above results are modeled relative to a Bin 5 baseline

- Modeled difference in level of the standards: Bin 5 vs. Bin 2.
- In reality, new standards would likely provide fewer benefits because many Bin 5 vehicles are certified well below the standard, and many are in fact 50-state vehicles certified in California as ULEVs.
- The costs are also modeled relative to a Bin 5 baseline, so the fact that many vehicles are actually cleaner today will also result in lower total costs.

[3] For information on Bin emission levels, see: http://www.epa.gov/greenvehicles/summarychart.pdf

The technology is described as follows:

- The technology relies on catalyst improvements—adding Rhodium, improved substrate/washcoat, and 900 cpsi density (all vehicles are assumed to need these changes)

- All vehicles are assumed to have close-coupled catalysts (1 or 2)

- Increased use of electronically controlled air injection—100% implementation on everything except 4-cylinder engines

Engineering costs for this program are estimated to be approximately $90-250 per vehicle for LDVs to LDT4s.

- Based on an analysis similar to that done for Tier 2 and LEV-II, estimating penetration rates of emission control technologies, coupled with estimated costs for each technology.

- A significant driver of costs is the market price of Rhodium, which has varied in the last 5 years from below $1000 to above $6000 per Troy ounce. We used the 5-year average of $2200.

- <u>These costs are the result of a preliminary analysis intended to achieve rough estimates. An in-depth bottom-up detailed cost analysis would need to be done to support an actual Improved Catalyst Design regulatory program.</u>

- Most of the costs are for catalyst improvements—adding Rhodium, improved substrate/washcoat, and 900 cpsi density (all vehicles are assumed to need these changes)

Cost-effectiveness is $8,400 per ton for HC+NOx, and $17,500 per ton for NOx alone. Based on assumptions and variables in the analysis, these numbers can vary +/- 30%.

7a.2.2 Plug-In Hybrid Electric Vehicles

Plug-In Hybrid Electric Vehicles (PHEVs) are very similar to Hybrid Electric Vehicles, but with three significant functional differences. The first is the addition of a means to charge the battery pack from an outside source of electricity (usually the electric grid). Second, a PHEV would have a larger battery pack with more energy storage, and a greater capability to be discharged. Finally, a PHEV would have a control system that allows the battery pack to be significantly depleted during normal operation.

PHEVs offer a significant opportunity to replace petroleum used for transportation energy with domestically-produced electricity. The reduction in petroleum usage does, of course, depend on the amount of electric drive the vehicle is capable of under its duty cycle. PHEVs can lower localized emissions of criteria pollutants and air toxics especially in urban areas by operating on electric power. The emissions with this technology occur more from power generation outside the urban area at the power generation plant rather than from the vehicle tailpipe, which may provide health benefits for residents of the more densely populated urban areas. Unlike most other oil-saving technologies, PHEVs also use existing infrastructure for fueling with gasoline and electricity so large investments in fueling infrastructure are not required. Since emissions from utilities are capped by existing programs, increases in power generation are generally not expected to impact attainment of air quality standards.

For this analysis, we assumed that PHEVs would be available as passenger cars and as light trucks in all light truck weight classes by 2012. We assumed the following phase-in schedule for PHEVs (Table 7a.3) as a fraction of new vehicle sales for the period from 2012 to 2020. This is an illustrative example of what could be feasible for the market penetration of PHEVs based on reductions that are needed for attainment of the revised ozone NAAQS and EPA's internal expertise and judgment. Recent announcements by Toyota and General Motors that they plan to introduce PHEVs by 2010 provide additional support for these assumptions.

Table 7a.3: Plug-In Hybrid Percentage of Total Sales of New Vehicles by Year

Year	Percentage of New Vehicles
2012	1%
2013	3%
2014	7%
2015	12%
2016	18%
2017	25%
2018	30%
2019	30%
2020	30%

We believe that the first consumers of PHEVs are likely to be the ones who can take best advantage of the PHEV while still operating on an overnight charge, i.e., urban and suburban residents with shorter commutes. We also assume continuing improvements in the range of PEHVs while operating on the overnight charge. For this analysis, we assumed that 70% of the VMT of PHEVs would be powered by the overnight charge rather than the vehicle engine and would have no direct exhaust emissions.[4] We used that estimate, and the assumptions of vehicle sales given above, to adjust the travel fractions in EPA's MOBILE6.2 emission model to account for the impact of reduced emissions for each model year of PHEVs.

All light-duty gasoline vehicles and trucks: Affected SCC:

- 2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types

[4] Note that this assumption is different than the assumption used in the payback analysis used to determine costs of PHEVs in: *Interim Report: New Powertrain Technologies and Their Projected Costs*. U.S. E.P.A, October 2005. http://epa.gov/otaq/technology/420r05012.pdf. That study assumes that only 30% of PHEV VMT is powered by overnight charge, but still shows a positive payback potential.

- 2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
- 2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types

Using the assumptions and methods described above, we estimated that HC emissions would be reduced by a range of 2.4% to 3.9% for passenger cars and light trucks (reductions vary by vehicle class). For NOx, we estimate reductions in the range of 1.6% to 2.5% for passenger cars and light trucks.

For purposes of this RIA, we identified this measure as a no cost strategy i.e., $0/ton NOx. Plug-in hybrids have upfront capital costs, but these costs can be fully recovered by the fuel savings during the life of the vehicle. According to research conducted by the EPA, the potential consumer payback for the hypothetical PHEV midsize car and large SUV can be calculated from the modeled fuel economy and projected cost of the vehicle package[5]. Using a retail price markup factor of 1.26 from the projected cost, the additional cost of a PHEV midsize car over the base vehicle is $6,072. The large SUV is projected to cost $7,884 more than the comparable base vehicle.

Appling these costs, the modeled fuel economy, and the standard economic assumptions used in this analysis of $2.50 per gallon gasoline price, 7% discount rate, and a 14 year life with annual VMT taken from the MOBILE6 model, results in consumer payback shown below. The payback period for the midsize car is 10.7 years, and 7.5 years for the large SUV.

Table 7a.4: Cost Effectiveness of PHEV Midsize Car and SUV

	Midsize Car	Large SUV
Incremental Vehicle Price	$5,646	$8,577
Fuel Economy Gain	126%	92%
Tailpipe CO2 decrease	56%	48%
Discounted Fuel Savings	$6,493	$11,751
Discounted Electricity Cost	$929	$1,346
Discounted Brake Savings	$376	$533
Reduced Fueling Time Savings	$395	$428
Lifetime Savings	$688	$2,789
Payback Period	10.7 years	7.5 years

Improved After-Market Catalysts

Both EPA and CARB have standards in place for aftermarket catalysts. CARB now requires higher quality replacement catalysts for OBDII vehicles and is considering expanding that requirement to pre-OBDII vehicles as well. (Even though higher quality, these replacement catalysts do not constitute a new standard for the vehicle—they just bring it closer to its original as-new performance level.) CARB has done testing and has

[5] Draft Revision to: *Interim Report: New Powertrain Technologies and Their Projected Costs*. U.S. E.P.A., October 2005. http://epa.gov/otaq/technology/420r05012.pdf

found that substantial emission reductions can be had by upgrading the quality of aftermarket catalysts.

Applying the proposed aftermarket catalyst requirements to the national fleet would bring about nationwide reductions. According to the Manufacturers of Emission Controls Association (MECA), approximately 3 million aftermarket catalysts are sold each year.

Estimated benefits are derived by comparing performance of existing replacement catalysts to that of the proposed catalysts. The difference is applied to the 3 million vehicles in the fleet that get aftermarket replacement catalysts.

All light-duty gasoline vehicles and trucks: Affected SCC:

- 2201001000 Light Duty Gasoline Vehicles (LDGV), Total: All Road Types
- 2201020000 Light Duty Gasoline Trucks 1 (LDGT1), Total: All Road Types
- 2201040000 Light Duty Gasoline Trucks 2 (LDGT2), Total: All Road Types

The table below (Table 7a.5) shows the emissions of the current aftermarket catalysts at 25,000 miles and the performance of the OBDII-type aftermarket catalysts at the same mileage. The emission reductions from improved aftermarket catalysts are substantial, even for Tier 0 vehicles.

Table 7a.5: Emissions of Aftermarket Catalysts

	Current Aftermarket Catalysts		Proposed Aftermarket Catalysts		Percent Reduction	
Category	**HC**	**NOx**	**HC**	**NOx**	**HC**	**NOx**
Tier 0	0.600	2.4	0.1750	0.20	71%	92%
Tier 1	0.600	2.4	0.1350	0.15	78%	94%
TLEV	0.600	1.6	0.0580	0.20	90%	88%
LEV	0.600	1.6	0.0250	0.05	96%	97%
ULEV	0.450	1.2	0.0125	0.07	97%	94%
LEV II LEV	0.450	1.2	0.0300	0.07	93%	94%
LEV II ULEV	0.450	0.8	0.0125	0.07	97%	91%
LEV II SULEV	0.375	0.8	0.0100	0.02	97%	98%

Based on this information, if starting in 2010 we required the 3 million replacement catalysts installed each year to meet these standards, by 2020 there would be 15 million vehicles with such catalysts left in the fleet (the other 15 million are assumed to be scrapped during this time period). In 2020, the emission reductions we calculate are as follows:

Table 7a.6: Emission Reductions from Replacement Catalysts

	HC	NOx
LDGV	3.5%	7.1%
LDGT1	3.4%	7.0%
LDGT2	3.6%	7.1%
LDGT3	3.7%	7.2%
LDGT4	3.9%	7.3%

Both EPA and CARB have standards in place for aftermarket catalysts. CARB now requires higher quality replacement catalysts for OBDII vehicles and is considering expanding that requirement to pre-OBDII vehicles as well. (Even though higher quality, these replacement catalysts do not constitute a new standard for the vehicle—they just bring it closer to its original as-new performance level.) CARB has done testing and has found that substantial emission reductions can be had by upgrading the quality of aftermarket catalysts.

Estimated engineering cost of the proposed replacement catalyst is $275, compared to approximately $100 for current replacement catalysts. These cost numbers are based on a review of prices published on the internet for OBDII and pre-OBDII replacement catalysts.[6]

Table 7a.7: CARB Cost Effectiveness for Improved After Market Catalysts

Category	NOx + HC	NOx only	HC only
Tier 0	$1,423	$1,722	$8,187
Tier 1	$1,353	$1,665	$7,238
TLEV	$1,889	$2,774	$5,917
LEV	$1,659	$2,378	$5,488
ULEV	$2,275	$3,329	$7,186
LEV II LEV	$2,090	$2,887	$7,567
LEV II ULEV	$2,736	$4,419	$7,186
LEV II SULEV	$2,782	$4,232	$8,120

For the O3 RIA, we used an average cost of $3,700/ton NOx reduced.

7a.2.3 Summary of Emission Reductions and Costs

Total emission reductions and costs for the 3 control measures included in the alternative baseline analysis are presented in Table 7a.8:

Table 7a.8: NOx Emission Reductions and Costs for Alternative Baseline Analysis

Sector	Control Measure	Annual Emission Reductions (Tons)	Total Cost (M$)
Onroad	Improved Catalyst Design	77,000	$1,600
	Plug-In Hybrid	22,000	$---

[6] See: www.discountconverters.com and autopartswharehouse.com

Improved After-market Catalyst	70,000	$260
TOTAL	**169,000**	**$1,900**

7a.3 Methods for Estimation of Benefits ($/ton NOx reduced)

We estimated the monetary value of the 169,000 tons of mobile source NOx emission reductions in our baseline through a benefit per ton approach. Because NOx is both an ozone and PM2.5 precursor, these reductions will yield both reductions in the ambient levels of these pollutants as well as monetized benefits. Because these reductions occur in the mobile source sector, we decided to estimate total ozone benefits by imputing an ozone benefit per-ton estimate from the soon-to-be-promulgated Locomotive and Marine Diesel Rule. While this rule does not affect an identical set of sources, it is a reasonable representation of the benefits of emission reductions in mobile source emissions, which is the sector of interest. We have included these benefit per-ton calculations in a separate Technical Support Document (TSD). To estimate the PM2.5 co-benefits we used a set of benefit per-ton estimates consistent with the main analysis. The process for deriving these estimates can be found in the same TSD.

The range of total combined ozone and PM2.5-related 2020 benefits associated with the emission reductions are between $360 million to $3.1 billion in 2006$ using a 3% discount rate. The lower-end of this range represents the combination of the assumption of no causality for ozone benefits and the Expert K PM mortality function for PM2.5 co-benefits (US EPA, 2006; US EPA, 2005). Using these same two combinations of studies, the range changes to between $330 million to $2.8 billion when using a 7% discount rate. It should be noted that these benefits are only a partial accounting of the total benefits associated with the mobile controls included in this sensitivity analysis. The sensitivity analysis does not estimate the benefits of other co-controlled emission reductions achieved by the mobile controls, such as VOCs (a precursor to ozone formation) and direct PM. The benefits presented here are therefore an underestimate of total benefits. Furthermore, these estimates are highly uncertain and are purely illustrative estimates of the potential costs and benefits of these mobile control strategies. We present them only as screening-level estimates to provide a bounding estimate of the costs and benefits of including these emissions controls in the ozone NAAQS control case for all standards. As such, it would be inappropriate to apply these benefit per-ton estimates to other policy contexts, including other regulatory impact analyses.

7a.4 References

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