Methods to Estimate Costs of :
(1) Unidentified Control Measures to Meet NAAQS Requirements and
(2) Direct Costs when Mark-up Factors are Present

A White Paper from the Second Section 812 Prospective Project Team
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SECTION 1: COSTS OF UNIDENTIFIED MEASURES

In support of EPA's section 812 analysis of the benefits and costs of the Clean Air Act Amendments (CAAA) of 1990, EPA has recently made available for SAB review a draft report presenting estimates of the compliance costs incurred by regulated industries as a result of the Amendments. That draft included an estimate of the costs in 2010 and 2020 for local controls necessary to meet the 8-hour ozone and PM 2.5 NAAQS requirements, as well as the requirements of the Clean Air Visibility Rule. For both the ozone and PM 2.5 NAAQS requirements, the preliminary cost estimate is based on cost per ton estimates from the AirControlNET database of control measures - the costs therefore reflect only identified control measures, and not the full set of measures that might be implemented by 2020 to achieve attainment.

The purpose of this white paper is to present a set of options for estimating the cost of further, unidentified measures that may be necessary to meet NAAQS requirements. We first present background information, outlining the procedures used to date to develop preliminary estimates of the costs of identified measures and the need for unidentified measures. We then present three options and two additional variants on those options for consideration. We conclude with a discussion of our revised approach, considering the range of options, and a related issue, the treatment of unidentified measures in the air quality modeling step of the analysis.

We conclude that no clearly superior approach exists for the costing of unidentified measures. Each of the options we have identified involves speculative assumptions about how local jurisdictions will balance the costs and benefits of these measures, at what point they will find implementation of these measures to be too costly to justify to local constituencies, and the pace of innovation and learning that will occur to reduce the costs of these measures (including identified measures) over time. Our revised approach therefore consists of two components:

1. For the primary, national analysis of local controls to be included in the Second Prospective, use a fixed per ton cutoff for identified controls and estimate the cost of all unidentified controls at that fixed per ton rate. Currently, estimates have been developed using $10,000 per ton as the threshold, but we suggest consideration of a higher threshold, on the order of $25,000 to $30,000 per ton.
2. Based on currently available information on emission reduction targets, or perhaps as completion of the air quality analysis identifies residual nonattainment

in particular areas, select two to four specific nonattainment areas where significant additional unidentified reductions are necessary and apply each of the main options identified in this white paper to estimate the range of possible costs to be incurred to achieve compliance. In addition, as part of these local-level analyses, compare alternative cost assumptions to the specific estimated benefits of compliance with the NAAQS in each of these areas, using reduced form emissions estimation tools such as the Response Surface Model (RSM).

BACKGROUND

A persistent issue in the estimation of costs of compliance with NAAQS is the costing of emissions reductions in nonattainment areas where known and identified control measures are inadequate to meet the emission reduction requirement. In the previous two 812 studies, measures applied to make up the shortfall in meeting progress requirements and approaching attainment were called "unidentified measures." Given the inherent lack of empirical data on the costs of unidentified measures, and recognizing that there should be limits on the cost of measures which could be practically applied, a fixed cap of $10,000 per ton was applied. In both previous analyses, there were insufficient data to conclusively identify a target emissions reduction for attainment - as a result, unidentified measures were only an issue where identified measures with costs of $10,000 per ton or less were not sufficient to meet rate-of-progress (RFP) requirements in nonattainment areas.

The prior Council accepted this approach with little discussion, perhaps because this uncertainty was not a large contributor to overall cost or net benefit uncertainty. As a practical matter, the 812 Project Team did not consider the costing of unidentified measures a major issue since the approach was applied to a fairly small proportion of the total estimated emission reductions. However, in the current analysis the ratio of unidentified to identified measures is significantly higher than in the previous analyses, at least for selected nonattainment areas.

As of September 2006, the Project Team had completed an initial local control measure analysis to estimate emissions reductions and costs incurred by local jurisdictions. The emissions analysis was performed in three steps: 8-hour ozone NAAQS implementation; CAVR rule implementation; and PM NAAQS implementation. Our analysis assumed that measures put in place toward compliance with the 1-hour ozone NAAQS and the current PM10 NAAQS for historical years remain in place through the 2010 and 2020 target years - these include local controls identified by RPOs and which are described in detail in the draft emissions analysis report. Note that, because of a lack of data on targets for 8-hour NAAQS compliance for California, the analysis conducted as of September 2006 did not reflect costs for California. An 8-hour ozone NAAQS compliance emissions and cost analysis for California is included in the February 2007 draft cost report, but was not available in time for consideration in this white paper.

Control measures were identified using the cost and control measure database contained in version 4.1 of AirControlNET, released in September 2005, with some updates to incorporate 1-hour ozone NAAQS local control measure information and additional onroad mobile source control measures. The primary analysis year for the ozone and PM NAAQS analyses was 2010; the Project Team then applied the same local controls identified for 2010 to generate results for 2020, except for those areas expected to come into compliance in 2020 through Federal controls alone. Exhibit 1 below provides a summary of the emissions and cost results for the ozone and PM NAAQS analyses current through September 2006.

EXHIBIT 1 SUMMARY OF PRELIMINARY OZONE AND PM NAAQS EMISSIONS AND COST RESULTS FOR 2020

CAAA RULE TRIGGERING LOCAL MEASURES	EMISSIONS REDUCTIONS FROM IDENTIFIED MEASURES	COSTS FOR IDENTIFIED MEASURES	ADDITIONAL EMISSIONS REDUCTIONS FROM UNIDENTIFIED MEASURES
8-hour Ozone NAAQS	350,000 tons VOC 288,000 tons NOx	Total cost: $2,530 million Average cost: ~ $4,000/ton	320,000 tons VOC 360,000 tons NOx
PM 2.5 NAAQS	109,000 tons SOx 53,000 tons NOx 19,000 tons PM2.5	Total cost: $552 million Average cost: ~ $3,000/ton	Not estimated

Notes: Ozone NAAQS analysis does not include California non attainment areas; a separate analysis is currently underway to supplement the emissions and cost estimates for California. PM analysis does not include any estimation of the need for unidentified measures from residual nonattainment. Estimates based on application of $10,000 per ton threshold for ozone RFP and any additional measures to come into compliance, and model SIP for PM compliance.

Source: Emissions Estimates from Emissions Projections for the Clean Air Act Second Section 812 Prospective Analysis: Draft Report, Prepared for USEPA by Industrial Economics and EH Pechan and Associates, June 2006 (SAB/AQMS review draft of June 23, 2006). Cost estimates from Clean Air Act Second Section 812 Prospective Cost Analysis: Draft Report, Prepared for Industrial Economics by EH Pechan and Associates, September 2006.

EXHIBIT 2 ALLOCATION OF IDENTIFIED AND UNIDENTIFIED CONTROLS FOR 8-HOUR OZONE NAAQS COMPLIANCE

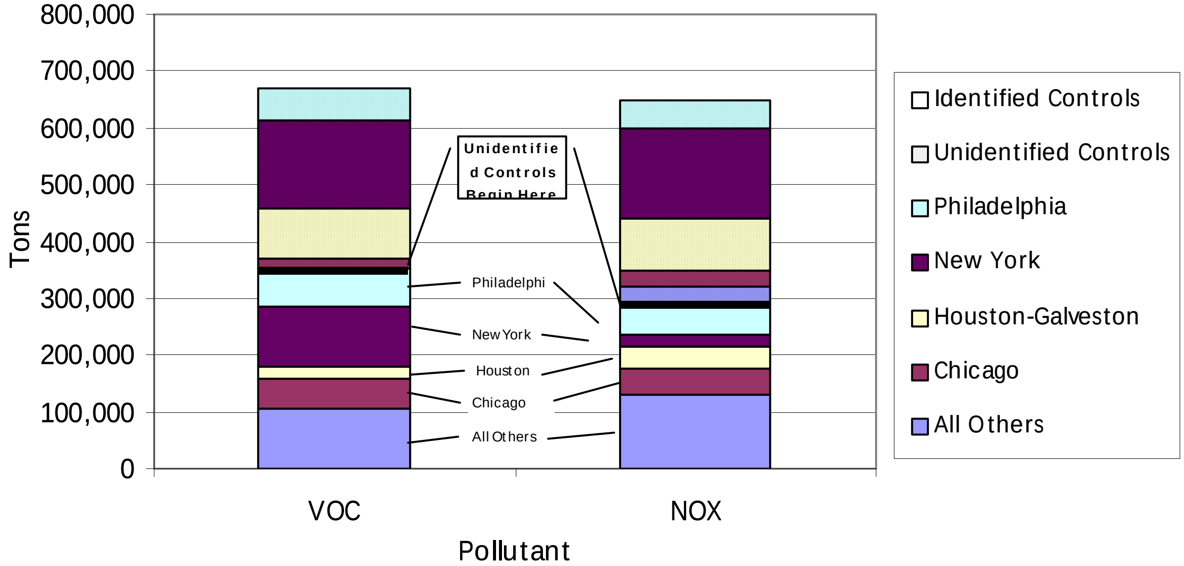
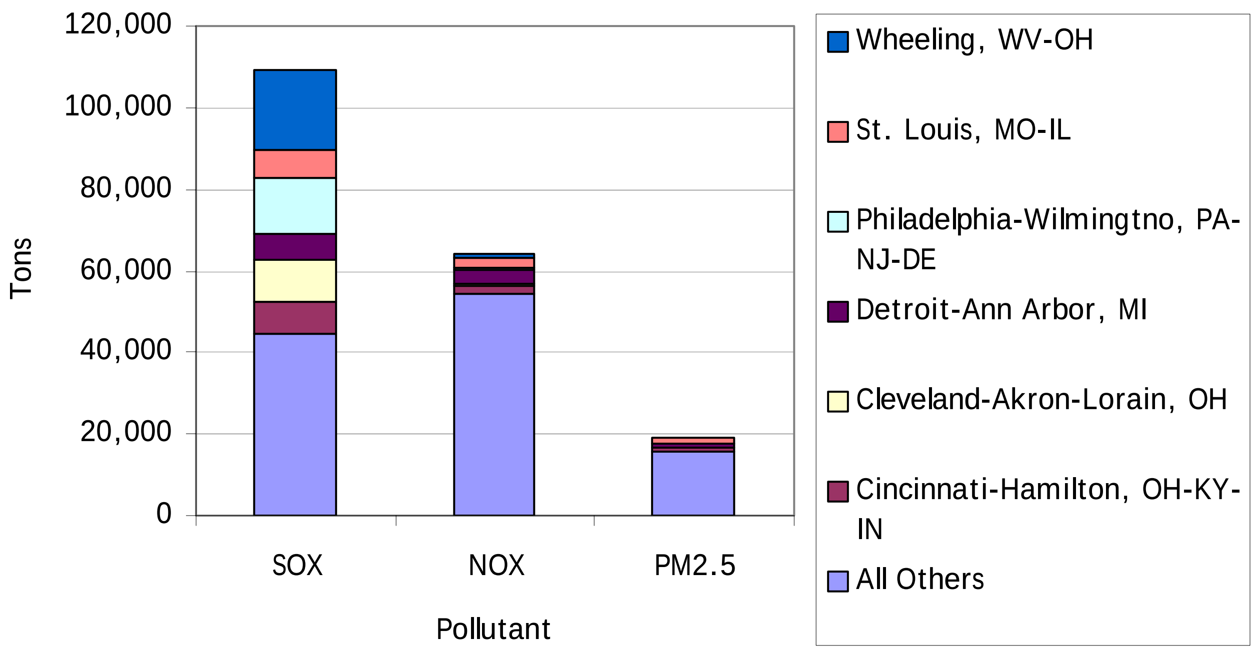


EXHIBIT 3 ALLOCATION OF IDENTIFIED CONTROLS FOR PM2.5 NAAQS COMPLIANCE



The emissions estimates summarized in Exhibit 1 reflect the following key analytic assumptions:

- ***8-hour ozone NAAQS:*** Analysis scope included all areas identified as being in nonattainment per the USEPA Phase I ozone implementation rule designations [70 FR 71612], except California areas (as noted above). Identified measures included application of I/M (without consideration of a cost threshold), RACT, and RFP. Unidentified measures applied were based on emissions targets for full attainment identified in the ozone implementation rule.[1] Identified measures may include source/controls within a 100 km radius for VOC reductions and within a 200 km radius for NOx reductions, and are selected on a least cost basis, but no measures were applied if their cost exceeded $10,000 per ton. The 8-hour ozone nonattainment areas not addressed in the emissions analyses are either projected to attain the NAAQS by 2010 or 2020 based on projected emission changes since their designation, or they are California ozone nonattainment areas for which no reliable emission reduction targets were available at the time.
- ***PM2.5 NAAQS:*** Analysis scope includes 39 PM2.5 nonattainment areas required to meet the PM2.5 standard by 2010, as identified in USEPA's September 8, 2005 proposed implementation rule. Identified measures included application of reasonably available control measure (RACM) and RACT control programs, as well as application of a list of measures in a "model SIP" in all 39 nonattainment areas. Because area-specific SIP control measures and emissions reduction targets were not available for this analysis, the Project Team developed a representative model SIP control program based on available control measures in AirControlNET for primary PM2.5 , SO2 and NOx. Model SIP measures were applied up to the point where their cost-effectiveness was less than or equal to a threshold value of $10,000 per ton. Point source and EGU control measures in AirControlNET were applied only to sources with annual emissions greater than 100 tons, as suggested in the EPA proposed implementation rule. Because no emissions reductions targets for attainment were available at the time, no unidentified measures analysis was possible.

As shown in Exhibit 1, the draft ozone NAAQS emissions analysis indicated that an additional 352,000 tons of unidentified VOC reductions would be needed to achieve attainment outside of California. Applying known identifiable control measures are insufficient to achieve the needed VOC emission reductions to attain the 8-hour ozone NAAQS in four nonattainment areas outside of California: Chicago, Houston-Galveston, New York, and Philadelphia (see Exhibit 2). In addition, the draft analysis indicated that an additional 324,000 tons of unidentified NOx reductions would be needed to achieve attainment outside of Calfornia. Roughly half of these measures (149,000 tons) would be needed in New York, large reductions would be needed in Houston, Philadelphia,

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[1] See Pechan, 2005, Potential Impacts of Implementation of the 8 hour Ozone NAAQS—Technical Support Document, prepared for EPA-OAQPS, July 2005.

Baltimore, Milwaukee, and Chicago, and smaller reductions (less than 2,000 tons) would be needed in Providence and Cleveland (see Exhibit 2).

Costs were estimated only for identified measures, and do not yet include costs for ozone NAAQS compliance in California. We anticipate that the ongoing California 8-hour ozone analysis will yield a large additional quantity of both identified and unidentified controls, and further expect the ratio of unidentified to identified controls to be much higher than for the rest of the country.

The costs summarized in Exhibit 1 above were estimated using the procedure applied in the locals control analysis reflected in the September 2006 cost report.[2] In summary, the Project Team used version 4.1 of AirControlNet with some updates to identify the least-cost measures for reducing VOC and NO_x emissions in each non-attainment area (or NOx, SO2, and PM2.5 measures for PM compliance). The cost analysis included the assumption that non-attainment areas would implement the least costly measures available in each area, contingent on their availability in the area. In general, measures were not applied if their control costs exceeded $10,000 per ton. The tiered approach to the ozone analysis, however, allows implementation of I/M controls where applicable with no cost cutoff. The effective marginal cost for I/M in these areas is between $25,000 and $30,000 per ton for VOC and NOx emissions reductions.

SUMMARY OF OPTIONS

To complete the cost analysis for the 8-hour ozone NAAQS, we need a technique for estimating the costs of unidentified measures. In addition, we may wish to consider an approach for estimating unidentified measures for PM NAAQS compliance. We have identified three main options for costing unidentified measures: 1) Cost all unidentified measures at a fixed dollar per ton; 2) Project an upward sloping cost curve using information from the full identified measure analysis on an area-specific basis; 3) Use available information on changes in costs per ton over time (to reflect such factors as learning by doing and induced innovation) to adjust any cost curve projection. In addition, we have identified three additional variants on options 1 and 2 that are also worth considering. Each of these options and variants is described below:

OPTION 1A: FIXED COST EFFECTIVENESS APPROACH WITH $10,000 CAP ON IDENTIFIED MEASURE COST

This option would fix the cost of all unidentified measures at $10,000 per ton, and would preserve the current cap of $10,000 per ton on identified measures. It is the simplest option to implement, and has precedent in both the Section 812 series of reports and several older RIAs. Costing unidentified control measures at $10,000 per ton was the method used in the analysis presented in Pechan's Draft Second Section 812 Prospective Cost Analysis report provided in September 2006; was utilized in EPA's 1997 Regulatory Impact Analyses for the Revised Ozone and PM NAAQS and Proposed Regional Haze Rule; and was used in The Benefits and Costs of the Clean Air Act: 1990 to 2010 (sometimes referred to as the First Prospective). In these prior analyses, this assumed

[2] E.H. Pechan & Associates, *Clean Air Act Second Section 812 Prospective Cost Analysis Draft Report*, September 2006.

cost for unidentified measures is coupled with an assumed "cut-off" for identified measures at $10,000 per ton.

The general argument for this option is that the relatively high cost of the unspecified measures reflects a strong incentive to innovate and develop new control measures that are less costly. The general argument against this option is that the $10,000 per ton cap appears arbitrary - we have been unable to identify an independent basis for establishing $10,000 per ton as a reasonable ceiling on the costs of NAAQS compliance measures. In addition, there is some evidence that areas are spending more than this amount on some existing measures, especially ones with the potential to improve transportation mobility, a factor which represents an important unquantified ancillary benefit of these programs (which would effectively reduce the perceived cost per ton attributed to pollution control motives).

OPTION 1B: FIXED COST-EFFECTIVENESS FOR UNIDENTIFIED CONTROLS WITH NO CAP ON IDENTIFIED CONTROL COST

A variant on Option 1 would remove the $10,000 per ton cap on unidentified controls, allow all identified measures in AirControlNET to be applied in each NAA, and then cost unidentified controls at a fixed dollar per ton consistent with the marginal identified control cost.

The argument for this option is that it makes full use of all information we currently have on identified controls in AirControlNET. The argument against this option is that many measures in AirControlNET, while perhaps appropriate for some areas, when applied in other areas may yield unrealistically and infeasibly high control costs, in some cases in excess of $1 million per ton. We would argue that, at costs of that magnitude, there would be both strong resistance to adoption of measures at the local level and an extraordinarily strong incentive to innovate either technologically or in measure design that would bring costs down.

OPTION 1C: FIXED COST-EFFECTIVENESS FOR UNIDENTIFIED CONTROLS WITH A HIGHER CAP ON IDENTIFIED CONTROL COST

Another variant on Option 1 recognizes that the $10,000 per ton cap does not have an independent basis for being a reasonable, generally applicable cut-off. A higher cap, and a higher cost per ton for unidentified measures, might be more appropriate, but there does not appear to be a strong justification for any particular alternative. The draft 2007 California South Coast Air Quality Management District plan does propose a threshold of $16,500 per ton for SIP evaluation, but the $16,500 threshold merely triggers more in-depth analysis of the measure's applicability; CARB provides no justification for the $16,500 as a "cut-off" value.[3] One option would be to use the effective marginal cost of I/M controls, which are applied by rule for some non-attainment areas, as a cutoff value. As noted above, the cost-effectiveness of the I/M program we apply is between $25,000 and $30,000 per ton for both VOC and NOx reductions.

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[3] See page 4-66 of the draft 2007 SCAQMD Air Quality Management Plan for discussion of the $16,500 threshold for more in-depth evaluation.

OPTION 1D: FIXED COST-EFFECTIVENESS FOR UNIDENTIFIED CONTROLS WITH A CAP ON IDENTIFIED CONTROL COST DETERMINED BY LOCAL AREA BENEFIT-COST CRITERIA

A third variant on Option 1 would attempt to establish a per ton cost-effectiveness threshold based on the area-specific per ton benefits of ozone and PM precursor control. An analysis of this type was conducted for the September 2006 PM2.5 NAAQS review RIA.[4] In that analysis, benefits per ton were estimated for four areas of the country and three pollutants (NOx, SO2, and direct PM2.5), for several individual source/pollutant combinations. The estimates ranged from $22,000 for non-EGU SO2 controls in the Midwestern US to $370,000 for non-EGU SO2 controls in the Western US. The RIA carefully notes, however, that these estimates are general approximations of the benefits/ton based on extrapolated benefit values from a Response Surface Model (RSM) analysis, and that the estimates should not be construed as the true value of benefits for a given area.

The argument for this variant is that the threshold cost-effectiveness value has an independent basis. The arguments against include that the analysis is admittedly an approximation based on simplified benefit analysis tools (the RSM) and that it would involve a complex re-application of AirControlNET using different cutoff values by region and pollutant/source combination. In addition, while the PM NAAQS RIA provides estimates of the cutoff values for PM NAAQS precursors, these estimates are not available for ozone precursors or for the joint benefits of both ozone and PM in cases where reducing precursor pollutant (e.g., NOx) yields both types of benefits; as a result, application of these estimates would imply inconsistencies across pollutants.

OPTION 2A: EXTRAPOLATED MARGINAL COST CURVE APPROACH

The 2006 National Ambient Air Quality Standards for Particle Pollution RIA followed a step-wise process to simulate attainment in all areas of the country with the alternative standards. This included applying “supplemental” carbonaceous particle controls on top of identified controls from AirControlNET. After the identified and supplemental controls were applied, EPA identified areas with continued residual nonattainment, and estimated the additional emissions reductions necessary to achieve compliance. Two areas of the country were involved in the analysis for this "third tier" of unidentified emissions reductions: Salt Lake City, UT; and several NAAs in California.

EPA estimated the cost of full PM2.5 NAAQS attainment by constructing a cost curve that reflects the rising marginal costs of pollution abatement. They used the calculated slope of the observed marginal cost curve as the basis of the extrapolated cost per microgram line that extends out to the targeted air quality increment.

For our analysis, instead of developing the marginal cost curves on a per µg basis, the Project Team could calculate marginal cost curves on a per ton basis and estimate the cost of the residual non-attainment increment by calculating the area under the extrapolated cost curves to derive a total cost estimate. Prior analyses might be used to identify the most cost effective pollutant/source combination on which to base the extrapolation, as precursors have differing effects on ambient concentrations.

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[4] See Table 3-1, page 3-4 from the RIA.

The argument for this option is that it takes advantage of available information on costs of identified measures - the method essentially extrapolates future costs by fitting a linear cost curve to all of the observed (identified) cost and emission reduction data. One argument against this option is that this extrapolation approach assumes no technological change that would shift the marginal cost curve downward. We believe it is highly probable that as areas work to develop control strategies to implement NAAQS, new technologies will be developed that will result in lower control costs.

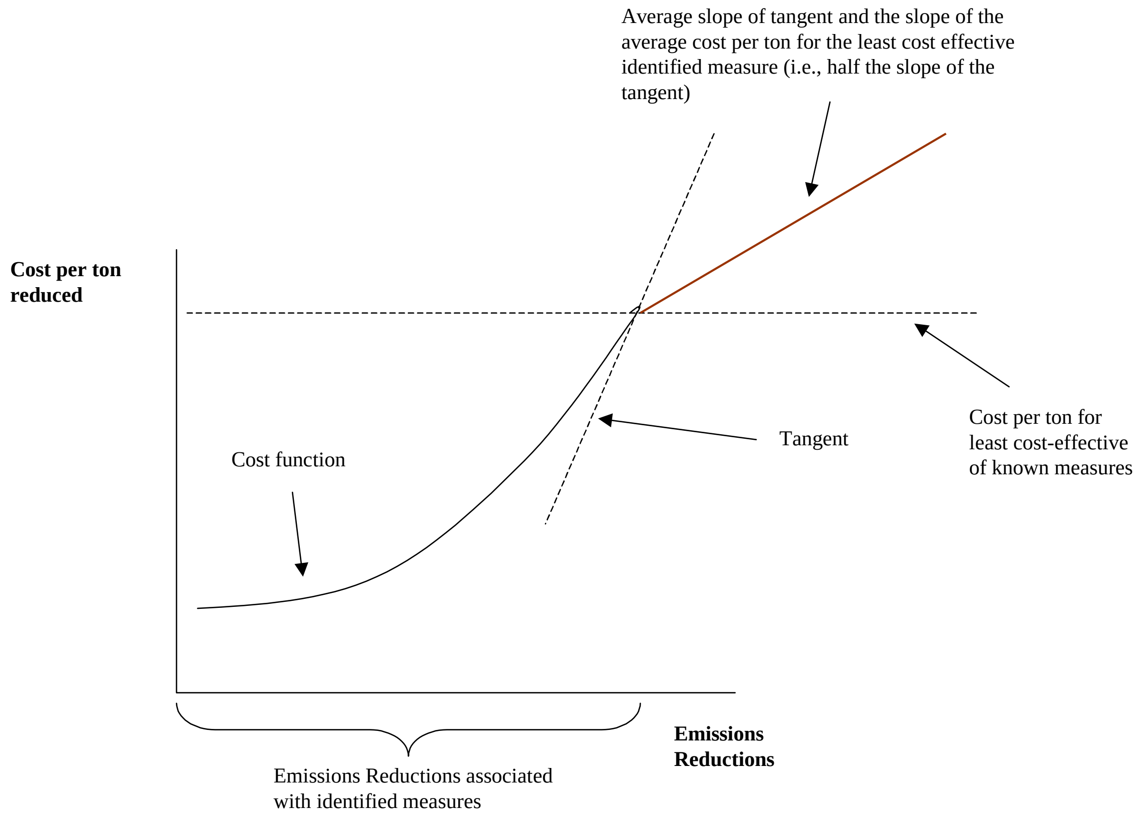
Another argument against this option is that, because there is a strong curvature to the observed data, at least in the California application described in the RIA, the slope of the linear extrapolation likely relies heavily on how the starting and ending points of the observed curve are determined. Starting points would presumably vary by area, depending on measures that might have been adopted for prior compliance with the 1-hour ozone and PM10 standards. Cost curve ending points might be determined based on some truncation of the full set of control measures in AirControlNET, in recognition that some measures have artificially high costs per ton simply because they apply to a very limited number of sources in a region that might be small emitters with high costs of controls.

OPTION 2B: ALTERNATIVE EXTRAPOLATION APPROACH

A variant on Option 2 might base the extrapolation on a smaller portion of the marginal cost curve. The project team might project costs based on consideration of both the slope of the tangent at the end of the marginal cost curve and the constant marginal cost curve (a horizontal line), as illustrated in Exhibit 4 below. Projections of the slope of the marginal cost curve might reasonably be developed based on slopes in the "window" of possible projections between the tangent line in Exhibit 2 and the horizontal line that represents a constant cost effectiveness at the cost per ton of the most expensive identified measure. For example, one line in this window, the line that bisects the tangent and the horizontal projection, is shown in Exhibit 4.

An argument against using the tangent line is that it is very likely to overestimate the future costs because of the effects of learning and innovation over time, which tend to reduce projected costs. While the bisection line implicitly acknowledges this effect, there is not independent analysis that suggests it is a good approximation of the effect of learning and innovation over time.

EXHIBIT 4 ILLUSTRATION OF EXTRAPOLATED MARGINAL COST ALTERNATIVES



OPTION 3: PROGRESS RATIO APPROACH

This option would attempt to make use of available information to reflect the impact of learning and innovation over time. EPA explored the use of progress ratios in the Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule in 1997.

The progress ratio is defined as one minus the percentage reduction in installed cost per unit for every doubling of cumulative production experience, relative to a base year. For example, typical progress ratios for gas turbines are about 0.95, implying a 5 percent reduction in cost per unit for a doubling of cumulative production experience. In some past analyses, cumulative production has also been proxied by a time variable. Using the formula below, the installed cost of a unit in a future year is related to the current unit installed cost, predicted production (measured as cumulative doublings in production), and the progress ratio.

$$InstalledCost_y = InstalledCost_{baseyear} \bullet ProgressRatio^{cumulativedoublings_y}$$

Some examples of progress ratios for various past and future technologies, either calculated or taken from the literature, are shown below in Exhibit 5. Progress ratios in the Exhibit range from 67 to 97 percent. The example of a so-called "mature" technology such as the magnetic ballast shows a 97 percent progress ratio which means that costs are not falling very quickly at all. On the other hand, a more advanced technology for the same end use, in this case the more efficient electronic ballast, suggests a 90 percent progress ratio. The pollution control technologies in Exhibit 5 -- including CFC substitutes and scrubbers -- appear to hover close to 90 percent. However, the table does not present pollution control technologies that look similar to those likely to be adopted for NAAQS compliance.

EXHIBIT 5 EXAMPLES OF PROGRESS RATIOS

TECHNOLOGY	PERIOD	CUMULATIVE PRODUCTION	$COST_{BASEYEAR}$	$COST_{Y}$	PROGRESS RATIO
Electronic Ballasts	1986-1993	52.7 million	$37.65	$18.23	90%
Magnetic Ballasts	1977-1993	629.3 million	$7.86	$6.47	97%
Fluidized Bed Coal	1987-1992	n/a	n/a	n/a	95%
Gas Turbines	1987-1992	n/a	n/a	n/a	95%
Wind Turbines	1987-1992	n/a	n/a	n/a	90%
Integrated Circuits	1962-1968	$828 million	$50.00	$2.33	67%
Low-E Windows	1993-2010	11.3 bsf	$2.90	$1.20	86%
CFC Substitutes	1988-1993	8.9 billion tons	$3.55	$2.45	93%
Photovoltaic	1975-1994	516 MW	$75/watt	$4/watt	70%
Solar Thermal	1996-2020	800 MW	$3335/kW	$2070/kW	90%
Gasified Turbines	1997-2000	156 MW	$2000/kW	$1400/kW	84%
Scrubbers	1985-1995	85,700 MW	$129/kW	$122/kW	88%
Source: Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule, EPA OAQPS, 1997.					

The argument for this option is that the "static" nature of other projection methods may lead to the overestimation of costs because the analysis would not capture the effects of learning by doing, technological improvement, and scale effects. EPA's experiences with technology advances, and the promise of numerous cleaner technologies emerging today, strongly suggest that technological innovation and learning by doing will continue to produce new, cleaner processes and performance improvements that reduce air pollution at lower cost.

The main argument against this approach is that the limited availability of data make determining an appropriate progress ratio very difficult. In the overall study, based on Council advice, the Project Team has concluded that adjustments for learning ought only be applied when there is a good match between the technology for which cost adjustment data are available and the control measure to which it might be applied. We believe it would be difficult to defend a particular progress ratio as most appropriate for unidentified NAAQS compliance measures, as there is no basis for evaluating whether there is a good match.

REVISED APPROACH

After careful consideration of the options identified above, we conclude that no clearly superior approach exists for the costing of unidentified measures. Each of the options we have identified involves speculative assumptions about the how local jurisdictions will balance the costs and benefits of these measures, at what point they will find implementation of these measures to be too costly to justify to local constituencies, and the pace of innovation and learning that will occur to reduce costs of these measures (including identified measures) over time.

Our revised approach consists of two components. First, for the primary, national analysis of local controls to be included in the Second Prospective, we suggest option 1C, using a fixed per ton cutoff for identified controls and estimating the cost of all required unidentified controls at the same fixed per ton cutoff variable. This approach has the advantage of being conceptually consistent with First Prospective, it is transparent, and it is easily implemented. We suggest that the value might be determined based on the effective cost per ton of VOC and NOx reductions for I/M, a program that applies by rule in many of the ozone nonattainment areas that require further unidentified controls. Further research into measures that individual areas have committed to apply already may provide further support for this value, or for another higher or lower value. Nonetheless, it appears that continued use of the $10,000 per ton value is probably not warranted, as we believe that many areas may already have adopted measures with cost-effectiveness in excess of this value.[5]

The key disadvantages of this approach are that there does not appear to be further basis for any fixed per ton cutoff. Nonetheless, none of the alternatives we have examined provide independent confirmation of their validity. The next component of our revised approach therefore suggests that the considerable uncertainty associated with costing unidentified controls be addressed in local scale analyses.

Second, we would conduct additional analysis of specific local areas after completion of the air quality analysis identifies residual nonattainment. We suggest that that the Project Team select two to four specific nonattainment areas where significant additional unidentified reductions are necessary and apply each of the main options identified in this white paper to estimate the range of possible costs to be incurred to achieve compliance.

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[5] Note that analyses conducted to date suggest an average cost for identified controls of approximately $3,000 to $4,000 per ton - however, those values were developed using the operating ceiling of $10,000 per ton for non-I/M identified controls. A higher ceiling would likely have yielded more identified measures and a higher average cost for identified measures.

Local scale analyses will allow the Project Team to examine measures at the margin, to contact local agencies to collect information on specific supplemental measures that might augment the identified measures in AirControlNET, and to examine a benefit-cost type criterion in a more focused manner. In addition, analyses at the local scale might also be informed by specific local experience on ex ante cost estimates to comply with NAAQS requirements at several points in time, better informing an application of a broad progress ratio approach. These local-level results would then be used, at a minimum, to supplement the primary national analysis results. If compelling results are obtained for some areas, we might choose to substitute the alternative results in the primary analysis for that area. If compelling results are obtained for all areas studied, we might reconsider the national-level cost methodology for unidentified measures.

In addition, as part of these local-level analyses, we suggest that a policy objective comparing local costs for unidentified measures to local benefits for these measures be pursued. The approach would acknowledge two distinct levels of analyses within the broader Section 812 framework. The first level would correspond to emissions and costs incurred for which we can readily identify measures for compliance. The specificity we can provide in terms of location, source category, timing, and cost effectiveness makes these measures most appropriate for analysis with the more precise and data intensive CMAQ air quality modeling.

The second level would correspond to the more uncertain unidentified measures. Analysis of the benefits of these unidentified measures might more reasonably be conducted with a less precise but more "nimble" air quality modeling too, such as the RSM. RSM is nonetheless capable of analysis of pollutant and sector specific analyses that might provide useful information on the relative merits of pursuing a range of different compliance strategies at the local level - we find this preferable to committing the major time and resource-intensive analytic tools such as SMOKE emissions process and the CMAQ air quality model to what are likely to be more speculative scenarios for local compliance. In addition, the simple dollar per ton approach to costing unidentified measures that we propose for the primary analysis would also be readily isolated so we could compare both the costs and the benefits of this more uncertain level of local control implementation.

SECTION 2: TREATMENT OF COSTS WHEN MARK-UP FACTORS ARE PRESENT

Many of the cost estimates presented in the draft direct cost report recently submitted to the SAB Council for review include a cost mark-up for the profits and/or overhead of regulated facilities (e.g., profits earned by regulated facilities on pollution controls that they must install as a result of the Amendments). Although overhead represents a legitimate cost that should be included in CAAA-related cost estimates, it is not clear that profit mark-ups for regulated facilities should be reflected in the project team's cost estimates. The purpose of this section of the white paper is to summarize the use of cost mark-up factors in the Second Prospective cost analysis and to outline an approach for excluding regulated facility profit mark-ups from cost estimates, where appropriate. The goal in adopting such an approach would be to identify any direct costs that might be more legitimately characterized as transfer payments and to exclude them from the analysis. The treatment of regulated facility profits in the draft cost report varies by source category, as summarized below:

> ***Electricity Generating Units (EGUs):*** To estimate the costs incurred by EGUs as a result of the Amendments, the project team is using the Integrated Planning Model (IPM), an optimization model of the EGU sector. EGU profits are not included in the cost estimates generated by IPM; however, the model includes property taxes in its estimates of EGU costs. Because property taxes represent a transfer rather than a real resource cost, the 812 project team will remove property taxes from the cost estimates generated by IPM.
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> ***Non-EGU Stationary Sources:*** Based on the available information, we do not believe that the unit cost values for non-EGU stationary sources in the September 2006 report reflect the profits of regulated facilities.
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> ***Mobile Sources:*** A small fraction of the mobile source (i.e., on-road and non-road sources) operating and maintenance costs presented in the draft cost report reflect a mark-up for the profits of vehicle manufacturers. Overall, these profit mark-ups make up less than 2 percent of the total costs associated with CAAA-related mobile source provisions. Although these profits represent costs to consumers who ultimately purchase vehicles affected by the Amendments, it is not clear whether such profits ought to be reflected in the project team's cost estimates or excluded from the analysis on the grounds that they represent a transfer from consumers to vehicle manufacturers.

The following section summarizes guidance from various EPA documents and the academic literature on the treatment of profits in the context of benefit-cost analysis. Following this discussion, we then provide a more detailed description, by source category, of how the profit of regulated facilities is treated in the draft cost report and how such profits could be excluded from the analysis.

CONCEPTUAL GUIDANCE ON THE TREATMENT OF PROFITS IN BENEFIT-COST ANALYSIS

To obtain guidance on how best to treat profits in the context of the section 812 analysis, we consulted EPA guidance documents and various academic sources. Although none of these sources specifically address the inclusion of regulated facility profits in analyses of pollution control costs, many discuss the treatment of profits and transfers in the context of economic analysis. Three general points emerge from these sources, as summarized below:

In economic terms, not all profit is equal. For the purposes of conducting economic analysis, it is important to distinguish between *accounting* profits and *economic* profits.[6] Economic profit is the difference between total revenues and total costs, including the opportunity costs of the factors of production. In contrast, accounting profits represent the sum of two components: (1) normal profit, which is the opportunity cost of resources owned by a firm and (2) economic profit (i.e., the difference between total revenues and total costs, including the opportunity costs of the factors of production).

Exhibit 1 presents an example that illustrates the difference between accounting profits and economic profits.

EXHIBIT 1 ACCOUNTING VS. ECONOMIC PROFITS

A small factory has annual accounting profits of $100,000. These profits reflect revenues of $200,000 per year, $70,000 in staff costs, and $30,000 in annual investments in air pollution controls. There is an owner-operator whose time would otherwise be worth $50,000/year as dictated by the market. In addition, the capital resources used for pollution controls could otherwise earn a return of 8 percent per year (i.e., $2,400 per year) if invested elsewhere.	
Monthly Revenues	$200,000
Monthly Staff Costs	($70,000)
Monthly investment in Pollution Controls	($30,000)
Accounting Profits	**$100,000**
Opportunity Cost of Owner's Time	($50,000)
Foregone Investment Income	($2,400)
Normal Profit (i.e., opportunity cost of resources owned by the firm)	**($52,400)**
Economic Profits	**$47,600**

Transfers should not be included in estimates of social costs. In some cases, the compliance costs incurred by a regulated entity may exceed the real value of the economic resources necessary for compliance.[7] The difference between these two values

[6] Our discussion of accounting profits and economic profits is based on Paul A. Samuelson and William D. Nordhaus, *Economics*, Fifteenth Edition, McGraw-Hill, New York, 1995; Robert H. Frank, *Microeconomics and Behavior*, Third Edition, McGraw-Hill, New York, 1997, and U.S. EPA, Office of Air Quality Planning and Standards, *OAQPS Economic Analysis Resource Document*, April 1999.

[7] Adapted from Edward M. Gramlich, *A Guide To Benefit-Cost Analysis*, Second Edition, Waveland Press, Prospect Heights, Illinois, 1990 and U.S. EPA, *Guidelines for Preparing Economic Analyses*, EPA 240-R-00-003, September 2000.

often represents a transfer between different parties that should not be included in estimates of social costs.

The purchase price for pollution control equipment represents a legitimate social cost. Equipment purchased to meet regulatory requirements often represents a significant portion of the costs associated with regulatory intervention. As indicated in NCEE's Guidelines for Preparing Economic Analyses, "the price of purchasing and operating new equipment required to meet a policy would provide a means of estimating the compliance costs for the industry."[8]

Based on these two points, we draw the following conclusions with respect to mark-ups for the profits of regulated facilities:

1. The definitions of accounting profits and economic profits presented above suggest that the first component of accounting profits (i.e., the opportunity cost of resources owned by a firm) should be included in estimates of the resources expended to comply with environmental regulation. Under the CAAA, capital is diverted from other uses under which capital owners could have earned a return. This foregone return represents a cost of the Amendments.

2. To the extent that economic profits represent a transfer from consumers to producers (or vice-versa), they should not be included in the project team's estimates of CAAA-related costs.

In applying these two points to the Second Prospective, we consider vendor prices for pollution control equipment, which include vendor profits, as costs incurred by regulated entities. In most cases, the application of this rule is relatively straightforward. For mobile sources, however, it is unclear whether profits associated with vehicle manufacturer mark-ups on pollution controls also represent a legitimate cost of the Amendments. Although the mobile source rules established under the Amendments regulate vehicle manufacturers, the pollution control devices required under the CAAA are ultimately purchased by U.S. households and businesses, for whom profit mark-ups are a cost. Therefore, a key issue is whether it is more appropriate to use the purchase price paid by vehicle manufacturers or the price paid by vehicle consumers as a metric of social costs in the context of CAAA-related emission requirements affecting motor vehicles.

In the following sections, we describe, by source category, how the profits of regulated facilities are incorporated into the cost estimates reflected in the September 2006 draft cost report and outline how these profits could potentially be excluded from the cost analysis.

ELECTRICITY GENERATING UNITS

As outlined in the draft cost report, the project team is using the Integrated Planning Model (IPM) to estimate the costs incurred by electricity generating units (EGUs) as a result of the Amendments. Under the cost accounting approach used by IPM, the model does not include EGU profits in its cost estimates, but property taxes are reflected in the

[8] U.S. EPA, Guidelines for Preparing Economic Analyses, EPA 240-R-00-203, September 2000.

model's estimates of EGU capital costs. Because property taxes represent a transfer rather than a cost to society, we will exclude property taxes from IPM's cost outputs, as outlined in the Second Prospective direct cost report.[9]

NON-EGU STATIONARY SOURCE MARK-UPS

The non-EGU stationary source cost estimates presented in the September 2006 draft report were developed from cost information included in AirControlNet.[10] This information was compiled in AirControlNet from EPA regulatory impact analyses, cost manuals, and several other documents. To the best of our knowledge, the unit cost estimates in AirControlNet for non-EGU stationary source control technologies do not reflect mark-ups for the profits of regulated facilities. For some pollution control devices, however, AirControlNet includes an engineering fee (charged by equipment vendors) representing 10 percent of the equipment purchase price.[11] This is consistent with several EPA stationary source control cost methods documents, which state that the total capital costs associated with pollution control equipment include the equipment purchase price plus, among other items, contracting fees (i.e., accounting profit for engineering and construction contractors) representing 10 percent of the equipment price.[12]

Similar to equipment costs, the non-EGU stationary source operating and maintenance cost estimates in AirControlNet, to the best of our knowledge, do not reflect cost mark-ups for regulated facility profits. This is consistent with the methods documents that we consulted, none of which include profits for regulated facilities in the cost accounting for estimating non-EGU stationary source operating and maintenance expenses. These sources recommend, however, that a standard overhead charge of 60 percent be applied to operating labor and materials costs when data on the overhead associated with individual technologies are unavailable. Because the cost information in AirControlNet was compiled from hundreds of sources, we do not know what overhead assumptions were used to develop several of the unit cost values included in AirControlNet. Nevertheless, the AirControlNet documentation indicates that the OAQPS recommended overhead rate of 60 percent is used for at least a limited number of technologies (e.g., non-selective catalytic reduction) and that a 140 percent overhead rate estimated by the Bureau of Labor Statistics is used for several others.

In the absence of information indicating that the non-EGU stationary source cost information in AirControlNet includes mark-ups for regulated facility profits, we have no basis for developing a methodology for excluding such profits from the non-EGU stationary source cost estimates presented in the September 2006 draft cost report. In addition, although the overhead assumptions for several control technologies may differ from the overhead recommendations in various control cost manuals, adjusting these

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[9] E.H. Pechan & Associates and Industrial Economics, *Direct Cost Estimates for the Clean Air Act Second Section 812 Prospective Analysis*, , prepared for James DeMocker, U.S. EPA Office of Air and Radiation, February 2007.

[10] For the purposes of this discussion, non-EGU stationary sources cover both non-EGU point sources and all non-point sources (i.e., area sources).

[11] Purchase prices for pollution control equipment likely reflect profits for equipment manufacturers and vendors, but it is unclear how much of a given purchase price reflects the profits earned by these firms.

[12] U.S. EPA, Office of Air Quality Planning and Standards, *EPA Air Pollution Control Cost Manual Sixth Edition*, EPA/452/B-02-001, January 2002 and U.S. EPA, Office of Research and Development, *Handbook: Control Technologies for Hazardous Air Pollutants*, EPA/625/6-91/014, June 1991. We also consulted several EPA Background Information Documents (BIDs).

values would require a detailed examination of each document supporting the stationary source control technologies included in AirControlNet. Because such an effort would require resources beyond the scope of this analysis, we recommend that the project team make no changes to the non-EGU stationary source overhead assumptions reflected in the September 2006 draft cost report.

MOBILE SOURCE MARK-UPS

To develop the mobile source (i.e., on-road and non-road sources) cost estimates presented in the September 2006 draft cost report, the project team relied upon cost information presented in regulatory impact analyses (RIAs) conducted in support of the mobile source rules promulgated under the CAAA. According to several of these documents, EPA used Retail Price Equivalent (RPE) factors to account for the mark-up on the vehicle manufacturing expenditures associated with each rule. Representing both the overhead and profit of regulated vehicle manufacturers, these mark-ups range from 26 to 29 percent in the mobile source RIAs that we consulted. EPA applied these RPE factors to the variable component of vehicle manufacturer costs.[13]

Several of EPA's RIAs for rules affecting on-road mobile sources provide a detailed description of how they used RPE factors to capture manufacturer overhead and profit. For example, the 1999 Tier 2/Sulfur regulatory impact analysis states: "To account for manufacturer overhead and profit, manufacturer incremental variable costs are multiplied by a Retail Price Equivalent (RPE) factor. The RPE factor we used in this analysis, 1.26, is the same one EPA has used in previous analyses for LDVs and LDTs."[14] Similarly, the Heavy-Duty Standards/Diesel Fuel RIA states that EPA marked up variable costs "at a rate of 29 percent to account for manufacturers' overhead and profit. For technologies sold by a supplier to the engine manufacturers, an additional 29 percent markup is included for the supplier's overhead and profit."[15] The 29 percent markup also applies to the 2004 heavy-duty vehicle standards (2 gram equivalent).[16] In contrast, the RIA for on-board vapor recovery systems includes a 26 percent markup for light-duty vehicles (LDVs) and light-duty trucks (LDTs), and a 27 percent markup for heavy-duty gasoline vehicles (HDGVs).[17] EPA's analysis of the cost of evaporative controls includes a 26 percent markup.[18] The RIAs for fuel control programs (e.g., reformulated gasoline,

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[13] Similar to our estimates of the costs incurred by vehicle manufacturers, our estimates of vehicle inspection and maintenance (I&M) costs may also include profits for manufacturers that produce vehicle components required under the Amendments. Some of these components may require periodic replacement, and the associated costs of replacement are incurred by consumers. Because information on repair costs is derived from several state analyses, which may or may not document the inclusion or exclusion of economic profit, resources currently available for the Second Prospective make it infeasible for the project team to review the relevant regulatory support documents to determine the extent to which profit is reflected in the I&M costs included in the September 2006 draft cost report.

[14] U.S. EPA, *Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements*, EPA420-R-99-023, December 1999.

[15] U.S. EPA, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, EPA420-R-00-026, December 2000.

[16] U.S. EPA, *Final Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines*, September 16, 1997.

[17] U.S. EPA, *Onboard Refueling Emission Regulations for Light-Duty Vehicles and Trucks and Heavy-Duty Vehicles*, December 1, 1993.

[18] U.S. EPA, *Final Regulatory Impact Analysis and Summary and Analysis of Comments: Control of Vehicular Evaporative Emissions*, February 1993.

diesel fuel sulfur limits, etc.) do not seem to explicitly include a markup for profit. These markups only seem to be applied to vehicle and technology controls.

Similar to the on-road RIAs cited above, EPA's regulatory impact analyses for rules affecting non-road sources also provide significant detail on their use of RPE factors. For example, the RIA for the non-road diesel Tier 2 and Tier 3 emission standards and the RIA for the control of large spark-ignition engines, non-road recreational engines, and recreational marine diesel engines both include a 29 percent mark-up on variable costs to account for manufacturers' overhead and profit. In both of these RIAs, the written text describing the application of this mark-up is the same as the language included in the on-road Heavy-Duty Standards/Diesel Fuel RIA. In addition, EPA's RIA for the Phase 2 Emission Standards for New Non-road Handheld Spark-Ignition Engines at or Below 19 Kilowatts applies a 29 percent cost markup to variable expenditures "to predict the costs related to the changes the engine manufacturers and their dealers (or mass merchandisers) need to make to comply with emission standards."[19] The RIA goes on to state that "Further downstream markups or other pricing strategies may further increase the price of the product, but these are not a necessary or direct impact of the new emission standards. Full cost pass through and profitability on increased costs are assumed."[20]

Many of the RIAs that we consulted reference a 1985 study conducted by Jack Faucett Associates as the basis for the RPE factors used by the Agency.[21] As indicated in Exhibit 2, the Faucett report recommends an RPE factor of 1.26 for the light-duty market, 1.27 for the heavy-duty gasoline market, and 1.36 for the heavy-duty diesel market. The manufacturer profit margins in Exhibit 2 reflect pretax *accounting* profits as a percentage of the cost of sales. In addition, only income from sales is reflected in pretax profits; interest income and other sources of income unrelated to vehicle production are not included. Similarly, the dealer profit margins in Exhibit 2 reflect the ratio of pre-tax profits to the cost of sales. As the data in Exhibit 2 indicate, profit represents a relatively small portion of the total mark-up for each vehicle type, ranging from approximately 13 percent of the mark-up for heavy-duty diesel vehicles to 22 percent of the mark-up for light-duty vehicles and heavy-duty gasoline vehicles. Furthermore, based on the data in Exhibit 2, we estimate that profit mark-ups represent less than 4.7 percent of the O&M costs associated with CAAA-related engine standards and less than 2 percent of the total mobile source costs presented in the September 2006 draft cost report.[22] Therefore, excluding these profits from the Second Prospective is unlikely to significantly affect the project team's estimates of CAAA-related mobile source costs.

To exclude profits from the mobile source cost estimates for the Second Prospective, the project team could use the information in the Faucett report to develop and apply

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[19] U.S. EPA, *Final Regulatory Impact Analysis: Phase 2: Emission Standards for New Nonroad Non-Handheld Spark-Ignition Engines At or Below 19 Kilowatts*, EPA420-R-99-003, March 1999.

[20] *Op cit.*

[21] Jack Faucett Associates, "Update of EPA's Motor Vehicle Emission Control Equipment Retail Price Equivalent (RPE) Calculation Formula," Report No. JACKFAU-85-322-3, September 1985.

[22] To estimate profit mark-ups as a percentage of total mobile source costs, we would ideally estimate the extent to which such profits are reflected in mobile source *variable* costs, because EPA's mobile source RIAs applied RPE factors to variable costs but not capital costs. However, because the draft cost report does not separate mobile source capital costs from variable costs, our 2 percent estimate assumes that the RPE factors were applied to all engine costs rather than just variable costs. Therefore, 2 percent is an overestimate of profit mark-ups as a percentage of total mobile source costs.

alternative cost mark-up multipliers that only account for manufacturer and dealer overhead, dealer interest expenses, and sales costs. As indicated in Exhibit 2, mark-up factors based only on these items would range from 1.191 for light-duty vehicles to 1.298 for heavy-duty diesel vehicles. Similar to the analyses conducted for the various mobile source RIAs cited above, these mark-up factors could be multiplied by the variable costs associated with each rule.[23] As suggested above, however, the overall impact of this change on the project team's cost estimates is likely to be minimal (i.e., less than 2 percent of total mobile source costs).

EXHIBIT 2 RETAIL PRICE EQUIVALENT FACTORS BY MOBILE SOURCE MARKET

ADDER	LIGHT-DUTY VEHICLE MARKET	HEAVY-DUTY GASOLINE VEHICLE MARKET	HEAVY-DUTY DIESEL VEHICLE MARKET
Manufacturer overhead	0.154	0.156	0.254
Manufacturer profit	0.038	0.042	0.028
Dealer interest expense	0.017	0.024	0.024
Dealer profit	0.020	0.018	0.018
Dealer sales commission	0.020	0.020	0.020
RPE Factor[1]	**1.26**	**1.27**	**1.36**
RPE Factor, excluding profit	**1.191**	**1.200**	**1.298**

Source: Jack Faucett Associates, "Update of EPA's Motor Vehicle Emission Control Equipment Retail Price Equivalent (RPE) Calculation Formula," Report No. JACKFAU-85-322-3, September 1985. The manufacturer data in this report reflect costs for the following manufacturers: General Motors, Ford, Chrysler, Caterpillar, Cummins, Mack, and International Harvester.

Notes:
1. The RPE factor for each market is estimated as one plus the sum of the individual mark-ups listed in the exhibit.

[23] We would not apply these mark-up factors to capital costs because capital cost estimates are already annualized based on the opportunity cost of capital.