APPENDIX B:

Methodology: Technology Price Estimates

In this report, the Office of Technology Assessment (OTA) has estimated the approximate retail price of technologies that range from those already present in the current light-duty vehicle fleet to those whose final design, choice of materials, and manufacturing process are not known. Some warning about these estimates and their sources is warranted:

1. ***For technologies far from commercialization, price estimates should be treated with skepticism.*** The only available manufacturing experience with these technologies is likely to be one-of-a-kind hand building. Redesigning to solve remaining problems may increase costs; mass production will certainly lower costs; the technologies will be redesigned to cut manufacturing costs; and learning over time will cut costs both through product redesign and through continual cost-cutting in manufacture. The magnitude of changes over time is not particularly predictable.

2. Although technology developers know the most about their technology's costs and remaining problems, their estimates of costs are particularly suspect. Technology developers are at the mercy of their finding sources--their company's directors, venture capitalists, and government agencies--and these sources generally will not proceed without assurances that costs will be competitive. The sole exception occurs when regulatory demands require proceeding with a technology regardless of market factors.

3. Alternative estimates of technology prices are exceedingly difficult to compare, because they rarely focus on precisely the same technological specifications and often differ in their inclusion of key cost components. For example, vehicle price estimates must include a range of expenses, including amortization of design costs, transportation, dealer markups, and so forth, but key cost components are frequently ignored in cost analyses.

OTA's analysis focuses on the incremental effect introduction of the technology will have on a vehicle's retail price, averaged across new vehicles. The price effect on an individual car or light truck model may be higher or lower than the estimated "retail price equivalent" (RPE), but these price variations represent cross subsidies between consumers. For example, marketing strategies may require certain models to be priced lower than other technologically similar models to compete efficiently in the marketplace, but <u>average</u> price increment is the focus of this analysis.

The analysis assumes that the industry is sufficiently competitive, and the technology and production methods are widely enough understood by competing companies, that manufacturers earn only their usually expected returns on capital--that is, they get no benefit by being able to charge a premium because no one else has the technology. In fact, most of the technologies considered in this report, except for battery and fuel cell technology, cannot be considered proprietary. This is also true of production methods, although different companies can be more or less efficient in production. In a competitive marketplace, all manufacturers must price their product so that the average producer earns a normal rate of return on capital; more efficient producers can gain market share by pricing lower than average at the expense of less efficient producers, or they can increase unit profits by charging the same as their less-efficient competitors.

In reality, the auto manufacturers are not a fully competitive industry but an oligopoly, in that three manufacturers control more than 70 percent of the U.S. market, and there are difficult barriers to entering the market. The picture is further complicated by a segmented car market that has some highly competitive market segments while others, such as large-car segments, are less competitive. The methodology used here is based on a manufacturer's "expected" rate of return on capital, which may be higher than the "normal" rate of return (if sales volume goals are attained) because the market is not perfectly competitive. Using this method, the calculated price impact may overstate the actual price impact in very market competitive segments, but may understate the impact in more oligopolistic segments.

Some technologies, such as diesel engines, are all already widely available, and their price effect is reported from direct observation of market prices. For most technologies, the method of estimating RPE is based on first estimating the cost of manufacturing a technology, then translating this to a retail price equivalent, assuming an expected rate of return. For those technologies that affect horsepower and performance, RPE is adjusted to account for the market value of performance. For example, the RPE of a four-valve engine would be determined as an increment to a two-valve engine of ***equal performance,*** which translates into a comparison with a larger displacement two-valve engine.

METHODOLOGY TO DERIVE RPE FROM COSTS

The RPE evaluation uses an approach followed by industry that includes the variable cost for each unit of the component or technology, and the allocation of the fixed costs associated with facilities, tooling, engineering, and launch expenses. The methodology has been used widely by regulatory agencies and is described in a report to the Environmental Protection Agency.[1] It has been adopted here with modifications suggested by recent manufacturer submissions to the U.S. Department of Transportation.

The methodology estimates both the amortization (based on the expected rate of return) of the investment cost of R&D engineering, tooling, production, and launch, and the labor, material, and plant operating costs, based on expected sales. If actual sales volume exceeds expected volumes, the manufacturer records a higher profit margin, but a lower volume can result in a loss. These excess profits and losses are balanced over a range of models which exceed, or are below, sales targets for a given manufacturer. The expected rate of return is set at 15 percent (real), which is higher than the normal rate of about 10 percent, and represents the risk-adjusted oligopoly rate of return.

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[1] U.S. Environmental Protection Agency, "Cost Estimation for Emission Control Related Components/Systems and Cost Methodology," Report No. 460/3-78402, 1978.

The methodology uses a three-tier structure of cost allocation. A specific component, such as a new piston or a turbocharger, is first manufactured by a supplier companv, or by a division of the manufacturer that is an in-house supplier (e.g., Delco supplies GM with electrical components). The supplier part “cost” to the manufacturer has both variable and fixed components--the variable cost is associated with materials, direct labor, and manufacturing overhead, and the pretax profit is calculated as a percentage of variable costs.[2] Fixed costs--tooling and facilities expenses--are based on amortizing investments undertaken before production and include the return on capital. In-house and external suppliers are treated identically, so that RPEs are not affected by outsourcing decisions, which is consistent with the idea of a competitive marketplace for subassemblies.

The second cost tier is associated with vehicle assembly, where all of the components are brought together (for example, the stamping plant producing body sheet metal parts can be treated as a “supplier” for costing). Manufacturer overhead and pretax profit are applied to the components supplied to an assembly plant plus the assembly labor and overhead.[3] Fixed costs include the amortization of tooling, facilities, and engineering costs, and include return on capital. The final tier leads to the retail price equivalent, and includes the markups associated with transportation, dealer inventory and marketing costs, and dealer profits.[4]

Table B-1 summarizes the cost methodology, and all of the overheads and profits are specified as standard percentage rates applied to variable costs.

Amortizing fixed costs and applying them to individual vehicles requires estimates of:

- fixed-cost spending distribution over time,
- return on capital,
- annual production capacity, and
- amortization periods

The fixed-cost spending occurs over five years before technology introduction in the marketplace, with most spending taking place in the two-year-period before launch. The rate of return on capital is assumed to be 15 percent real (inflation adjusted), consistent with the normal project rate used by the automotive industry (using this rate, every dollar of total investment in a project has a net present value of $1.358 at launch).

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[2] Supplier overhead and profit are both assumed to be 0.20, based on ibid., and auto industry submissions to the U.S. Department of Transportation.

[3] Manufacturer overhead assumed to be 0.25, manufacturer profit to be 0.20, W on ibid., and auto industry submissions to the U.S. Department of Transportation.

[4] Dealer margin assumed to be 0.25, based on auto industry submissions to the U.S. Department of Transportation.

[5] Energy and Environmental Analysis, Inc., “Documentation of the Fuel Economy, Performance and Price Impact of Automotive Technology,” report prepared for the Oak Ridge National laboratory, Martin Marietta EnergSystems, July 1994.

Plant capacity is 350,000 units a year, a "representative average" for automotive body-related technologies. Atypical model lifecycle is eight years, with a "facelift" at the midpoint in a model's product cycle; the appropriate period for amortization of engineering expenses related to the exterior design is four years. Engine and drivetrain components usually have a longer lifecycle than vehicle platforms, ranging from 8 to 10 years. In general, there are no major changes during this period, so that cost recovery over an 8-year-period is appropriate. Typical production capacity is 500,000 units a year for engines and transmission plants and designs. Calculations to derive unit costs assume operation at 85 percent capacity. Table B-2 shows the conversion method for deriving unit prices from variable and fixed costs for engine and drivetrain components.

It should be noted that the purpose of this analysis is not to derive the total cost, but the incremental cost, of a technology relative to the existing baseline technology. The analysis, therefore, estimates the ***difference*** in variable costs and investment between a technology and the one it supersedes. In this context, the choice is not between continuing production of an existing technology whose investment costs may have been fully amortized versus a new technology, but between a new model with baseline technology versus a new model with new technology. This is a ***crucial*** difference that potentially accounts for the great differences between some very high estimates of technology RPE and estimates presented here. The high estimates basically treat the fixed costs of the conventional vehicles as "sunk," making the conventional vehicles a much greater bargain than vehicles with new technology. This may be reasonable for the short term, but eventually manufacturers will have to redesign the conventional vehicles, including their powerplants, and the decision between conventional and new technology should then be based on the framework presented here.

TABLE B-1: Costing Methodolo~

Tier I **Supplier/Division Cost**	=	[Materials + Direct Labor+ Manufacturing Overhead] x [1 + Supplier Overhead+ Supplier Profit] + Tooling Expense+ Facilities Expense+ Engineering Expense
Tier II **Automanufacturer Cost**	=	[Supplier Cost + Assembly Labor+ Assembly Overhead] x [1 + Manufacturing Overhead+ Manufacturing Profit] + Engineering Expense+ Tooling Expense + Facilities Expense
Tier III Retail Price Equivalent	=	Manufacturer Cost x Dealer Margin
Notes		
Supplier Overhead	=	0.20
Supplier Profit	=	0.20
Manufacturer Overhead	=	0.25
Manufacturer Profit	=	0.20
Dealer Margin	=	0.25

SOURCE: Energy and Environmental Analysis, Inc., "Automotive Technologies To Improve Fuel Economy to 2015," report prepared for the Office of Technology Assessment, June 1995, p. 9-5.

TABLE B-2: Methodology to Convert Variable and Fixed Cost to RPE

. Supplier cost to manufacturers	= A
. Total manufacturer investment in tooling, facilities, engineering, launch	= B
. Unit cost of investment for drivetrain technology	= B X 1.358 +(500,000X 0.85X 4.487) ' c
. Automanufacturer cost	= (A x 1.4) + C = D
• RPE	= D X 1.25

[a]Unit cost for body technology = (B * 1.358)+(350,000x 0.85x 2.855)

SOURCE: Energy and Environmental Analysis, Inc., "Automotive Technologies To Improve Fuel Economy to 2015," report prepared for the Office of Technology Assessment, June 1995, p. 9-8.