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Interim Report: New Powertrain Technologies and Their Projected Costs

Executive Summary

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NOTICE
This interim report presents technical analysis of issues using data that are currently available to EPA. It does not represent final EPA decisions or positions. EPA welcomes comments from interested parties, and will make appropriate changes to this analysis as relevant information becomes available.

Abstract

This interim report projects the cost effectiveness, from a consumer perspective, of four technology strategies capable of improving new personal vehicle fuel economy over the next decade: packages of individual gasoline vehicle technologies, advanced diesel engines, gasoline electric hybrids, and diesel electric hybrids. These economic projections are based on a future high-volume scenario where economies-of-scale for these technologies are similar to those for conventional vehicles today. They do not account for the higher manufacturer and consumer costs during a transition period.

Based on EPA's review of the technical literature, all of these technology packages are projected to increase personal vehicle retail cost, ranging from around $1000 for a gasoline vehicle package in a midsize car to about $6000 for a diesel electric hybrid in a large SUV. But, by increasing vehicle fuel economy by 20% to 70%, these technologies will also reduce vehicle operating costs (primarily fuel expenditures). This report projects the consumer payback period, i.e., how many years it takes for a consumer to recoup in discounted operating savings an amount equal to the higher initial cost of the vehicle.

Based on a set of common economic assumptions, these technologies are projected to pay back to consumers in 2 to 11 years. Since all of these technologies pay back in less than the projected 14-year life of a vehicle, they would all provide net savings over a typical vehicle lifetime. These discounted lifetime savings range from $300 for one of the midsize car scenarios to over $4000 for some of the large SUV scenarios. In all cases, the payback period is shorter and the lifetime savings are greater when the advanced technologies are used in a large SUV rather than in a midsize car.

The assumed 14-year lifetime accounts for all the consumers who own the vehicle over that timeframe. Individual consumers who buy an advanced technology vehicle and sell the vehicle prior to the 14th year may or may not achieve payback depending on whether vehicle resale value reflects future operating cost savings.

This report makes two important conclusions:

- Multiple powertrain technologies have the potential to offer personal vehicle fuel economy improvements of 20% to 50% compared to today's gasoline vehicles; diesel electric hybrids have the potential to increase fuel economy by 70%.
- All of these technology packages pay back to consumers collectively over a 14-year timeframe, and many will pay back to individual consumers who own vehicles for less than 14 years.

These results should not be taken to imply that these technologies will necessarily move into the mainstream market in the near future. Decisions by manufacturers to invest in, and consumers to buy, new technologies involve many factors well beyond the scope of this paper. The point of this paper is not to predict future manufacturer or consumer behavior, but rather to project the cost effectiveness if they do adopt new personal vehicle technologies.

Executive Summary

This interim study examines the cost-effectiveness of automotive powertrain technologies with the potential for significantly improving new personal vehicle fuel economy in the next 5 to 10 years. It relies on independent projections of fuel economy improvement potential and incremental cost for individual technologies, and evaluates the technologies on a common economic basis. This study uses two consumer metrics for economic comparisons: the number of years that it would take for a consumer to pay back his or her up front investment in the fuel economy technology with discounted operating cost savings over time, and the net discounted consumer savings over a typical 14-year vehicle lifetime.

The economic projections in this report are based on a future high-volume scenario where the economies of scale and relative profit for the advanced technology vehicles approach those for high-volume conventional vehicles today. Costs for new technologies will undoubtedly be higher during a transition period when economies of scale will be much lower and there will be a series of initial investments, but estimates of these transition costs are beyond the scope of this paper. On the other hand, costs may ultimately be lower than those projected here for any technology that achieves long-term market maturity, as sustained market share would justify continued cost reduction that cannot be predicted at this time.

The four technologies evaluated in this study are:

- various packages of "incremental" improvements to gasoline vehicles
- advanced diesel engines
- gasoline/battery hybrid vehicles
- diesel/battery hybrid vehicles

The first three technologies are, at least in part, already commercialized in multiple personal vehicle models in one or more of the major world automotive markets.

This study evaluates the new powertrain technologies in two specific vehicle applications: large sport utility vehicles (SUVs) with four-wheel drive, and midsize cars with front-wheel drive. In general, this report assumes no change in vehicle size or 0-to-60 mile per hour acceleration performance; however, some of the referenced literature anticipates an increase in acceleration or torque performance for the diesel and hybrid vehicles (which is consistent with current market trends). Assuming equal fuel tank size, advanced technology vehicles will always provide increased vehicle range relative to conventional vehicles.

This analysis requires both technology-specific inputs as well as a generic set of common economic assumptions.

The primary technology-specific inputs are projections of fuel economy improvement potential and incremental retail cost. EPA reviewed the technical literature and selected technology projections by independent experts for each of the technologies. The two sets of technology projections for gasoline vehicle technology packages were derived from studies by the National

Academy of Sciences (NAS) and the Northeast States Center for a Clean Air Future (NESCCAF). One set of diesel vehicle projections was based on work done by FEV Engine Technology, Inc. and EPA, while the second was based on a study by Oak Ridge National Laboratory (ORNL). The two sets of technology projections for gasoline/battery hybrid vehicles were drawn from reports by the Electric Power Research Institute (EPRI) and ORNL. Finally, EPA derived the technology projections for diesel/battery hybrids based on information from several sources. In order to put all of the cost projections on a comparable basis, EPA adjusted cost projections of the independent studies to reflect the retail markup used by EPA in regulatory decisions.

Important technology-specific inputs are shown in the first three columns of Tables ES-1 through ES-4 (for Gasoline Vehicles, Advanced Diesel Vehicles, Gasoline/Battery Hybrids, and Diesel/Battery Hybrids, respectively).

The technology packages are projected to improve fuel economy from 20% (NAS gasoline technology package for the midsize car) to 72% (EPA diesel/battery hybrid for the large SUV). The incremental prices of the various technology packages are predicted to range from $712 (NAS gasoline technology package for the midsize car) to $5912 (EPA diesel/battery hybrid for the large SUV).

Table ES-1: Key Results for Gasoline Vehicles

		Fuel Economy Improvement (%)	CO2 Reduction (%)	Vehicle Price Increase* ($)	Consumer Payback (years)	Lifetime Savings ($)
Large SUV	NAS	42%	30%	$1,467	1.8	$4,386
	NESCCAF	31%	24%	$1,619	2.5	$3,288
Midsize Car	NAS	20%	17%	$712	3.8	$897
	NESCCAF	41%	29%	$1,318	3.9	$1,552

* Cost values adjusted to reflect use of EPA's 1.26 retail markup factor as discussed in Section 1.4.2.

Table ES-2: Key Results for Advanced Diesel Vehicles

		Fuel Economy Improvement (%)	CO2 Reduction Vehicle (%)	CO2 Reduction Lifecycle[1] (%)	Vehicle Price Increase*	Consumer Payback (years)	Lifetime Savings ($)
Large SUV	FEV/EPA	41%	18%	21%	$1,760	2.1	$4,284
	ORNL	33%	14%	16%	$2,560	4.1	$2,597
Midsize Car	FEV/EPA	40%	18%	21%	$1,252	3.8	$1,563
	ORNL	33%	14%	16%	$1,810	7.7	$634

* Cost values adjusted to reflect use of EPA's 1.26 retail markup factor as discussed in Section 1.4.2.

[1] This column adds the difference in diesel fuel production refining impacts to the vehicle CO2 reduction figures. On a lifecycle basis, the total benefit of diesel engines is somewhat higher because there are higher per-gallon energy losses for gasoline production than for diesel production.

Table ES-3: Key Results for Gasoline/Battery Hybrid Vehicles

		Fuel Economy Improvement (%)	CO2 Reduction (%)	Vehicle Price Increase* ($)	Consumer Payback (years)	Lifetime Savings ($)
Large SUV	EPRI	52%	34%	$4,464	5.0	$3,179
	ORNL	35%	26%	$3,039	4.1	$2,882
Midsize Car	EPRI	45%	31%	$2,500	7.4	$934
	ORNL	40%	29%	$2,683	9.5	$509

* Cost values adjusted to reflect use of EPA's 1.26 retail markup factor as discussed in Section 1.4.2.

Table ES-4: Key Results for Diesel/Battery Hybrid Vehicles

		Fuel Economy Improvement (%)	CO2 Reduction Vehicle (%)	CO2 Reduction Lifecycle (%)	Vehicle Price Increase* ($)	Consumer Payback (years)	Lifetime Savings ($)
Large SUV	EPA-derived	72%	33%	35%	$5,912	5.8	$3,321
Midsize Car	EPA-derived	71%	33%	35%	$4,123	11.4	$344

* Cost values adjusted to reflect use of EPA's 1.26 retail markup factor as discussed in Section 1.4.2.

To ensure methodological consistency in the economic comparisons (from a consumer perspective of the various technologies), this study evaluates each technology on a common economic basis with the following assumptions:

- economies-of-scale based on a high-volume, mature production scenario
- retail markup factor of 1.26
- downward laboratory-to-road fuel economy adjustment of 0.85
- 14-year vehicle miles traveled profile based on EPA's MOBILE6 emissions model
- nominal gasoline and diesel fuel price of $2.25 per gallon
- discount rate of 7 percent per year
- equivalent operating costs except for fuel expenditures and, for hybrid vehicles, brake maintenance expenditures
- no federal tax credit for hybrids or diesels
- no market externalities

The final two columns of Tables ES-1 through ES-4 show projections for the two most important economic outputs of this analysis: consumer payback and net lifetime consumer savings. Projections of the consumer paybacks for the various technologies range from about 2 years (for both gasoline packages and the FEV/EPA diesel package for the large SUV) to over 11 years (EPA diesel/battery hybrid package for the midsize car). In every case, the analysis projects that the new technologies will have shorter payback periods for an owner of a large SUV than for an owner of a midsize car. Industry statements suggest that cost paybacks of 3-4 years or less are generally necessary to stimulate market-driven introduction of new technologies. Several of the technologies appear to meet this threshold.

Since all of the technology packages have projected consumer payback periods of less than 14 years, they also have projected net lifetime consumer savings as well. The projected net lifetime savings range from $2600 to $4400 for large SUVs and from $300 to $1600 for midsize cars. These lifetime savings will accrue collectively to all individual consumers who own the vehicle during the assumed 14-year lifetime. Individual consumers who buy a new advanced technology vehicle and sell the vehicle prior to the 14th year will realize smaller savings (and even net costs if they sell before the payback period) unless vehicle resale value reflects the future savings associated with the technology.

The actual fuel economy improvement and cost of emerging powertrain technologies will not be known unless and until they are commercialized and sustain reasonable economies-of-scale. Such comparisons are certain to change as these technologies continue to be developed and refined. It is also likely that the best powertrain choices for individual vehicle models will vary by manufacturer, vehicle class, and/or consumer preferences with respect to vehicle attributes other than the economic metrics used in this paper.

This report makes two important conclusions:

- Multiple powertrain technologies have the potential to offer personal vehicle fuel economy improvements of 20% to 50%, and diesel electric hybrids have the potential to increase fuel economy by 70%.
- All of these technology packages pay back to consumers collectively over a 14-year timeframe, and many will pay back to individual consumers who own vehicles for less than 14 years.

While no one can predict at this time which future technologies will be most popular, the technologies studied in this paper are projected to be cost-effective, provide significant fuel savings, and provide equivalent or better vehicle performance and utility.

These results should not be taken to imply that these technologies will necessarily move into the mainstream market in the near future. Decisions by manufacturers to invest in, and consumers to buy, new technologies involve many factors well beyond the scope of this paper. The point of this paper is not to predict future manufacturer or consumer behavior, but rather to project the cost effectiveness, on a collective consumer basis, if they do adopt new personal vehicle technologies.

In August 2005, EPA asked 15 individuals to provide a technical review of a draft of this report. As of October 12, 2005, EPA had received comments from 8 of these reviewers. The most important comments, and EPA's responses to these comments, are summarized in Appendix E. EPA welcomes additional comments on this interim report.