**NADA COMMENTS TO NHTSA/EPA RE: MY 2017-2025 PROPOSED STANDARDS**

# Exhibit D

# Willingness to Pay for MY 2025 Fuel Economy Mandates: Government Estimates vs. Economic Reality

**Walton and Drake**

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Willingness to Pay for MY 2025 Fuel Economy Mandates: Government Estimates vs. Economic Reality

By Thomas Walton, Ph.D. and Dean Drake

Abstract

In their Preliminary Regulatory Impact Analysis (PRIA) the National Highway Traffic Safety Administration (NHTSA) and U.S. Environmental Protection Agency (EPA) found that U.S auto buyers will be willing to pay $6,000 per vehicle for standards achieving a combined 49.6 mpg in MY 2025 (56.0 mpg for cars and 40.3 mpg for light trucks) at $3.54 per gallon gasoline (in 2009dollars) – or $4,100 more than their estimated $1,900 per vehicle increase in retail price. They note that this estimate is inconsistent with the purchasing decisions of today's vehicle buyers who are willing to pay for no more than 30 mpg for the combined fleet with gasoline prices ranging between $3 and $4 per gallon. They surmise that this disparity, what they call an "energy paradox," can be explained by consumer myopia -- by auto buyers' irrational undervaluation of the present discounted value of future fuel savings. They ask for comments on this issue.

In response to a request from the National Automobile Dealers Association (NADA), Defour Group LLC has prepared this assessment. The discrepancy between the agencies' projections and the levels that auto buyers freely choose and can be expected to choose is found to be more than adequately explained by misspecification of the agencies' mathematical/engineering model. Their model overestimates willingness to pay because it ignores tradeoffs between fuel economy and other vehicle attributes that budget-constrained auto buyers value more highly, and it underestimates the retail price increases manufacturers will require in order to recover the costs of achieving the 49.6 mpg projection.

## I. Introduction

Mainstream economic research shows that NHTSA's $6,000 per vehicle estimate[1] of the present discounted value (PV) of fuel economy – what NHTSA calls "lifetime owner fuel savings" -- is too high by at least 75%. The literature also shows that NHTSA's estimate of the retail price increase necessitated by the proposed standards, of $1,900 per vehicle, is too low by at least 60%.[2] Making just these two adjustments off their baseline of MY 2016 34.1 mpg results in a $4,500 per vehicle *reduction* in willingness to pay to $1500 per vehicle, and a $1,100 per vehicle *increase* in retail price to $3,000 per vehicle (all estimates rounded to the nearest $100 per vehicle).[3] The fuel savings for a 49.6 mpg MY 2025 are worth $1,500 per vehicle, but it costs $3,000 to get them.

Net willingness to pay, the bottom-line number and what the agencies call "net lifetime owner fuel savings," (or the difference between the present value of the expected fuel savings less the increased retail price of the vehicle) is a *negative* $1,500. Of course, a lower and more realistic baseline would imply a still higher retail price increase and a still lower net willingness to pay.[4]

In fact, this estimate is conservative by comparison to those found in studies by economists at independent agencies, think tanks, and universities, *whose research NHTSA and EPA inexplicably ignore* which find that, even with the most optimistic assumptions about cost-effective fuel efficiency technologies and the highest conceivable trajectory for fuel prices, consumers would only be willing to pay for at most 37 mpg for the combined fleet in MY 2025.

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[1]Benefits derived from Table VIII-27b, page 715 of the NHTSA PRIA. The $6,000 per vehicle value for consumer willingness to pay for MY 2025 equals Total Private Net Benefits in line 4 of $101.2 billion divided by 17 million unit baseline sales in that year from Table III-A.3-1 of the PRIA (rounded to the nearest million units). The $1900 per vehicle increase in retail price comes from the proposed 2017-2025 rule page 74889 (December 2011) . We assume baseline unit sales as the relevant divisor because it is the starting point for the analysis – the point from which any sales effects would then be estimated. We could instead calculate the sales based on a new divisor that would reflect the increased consumer demand for vehicles carrying an effective net price reduction of the difference between the $6,000 in increased customer value and the $1,900 increase in retail price, or $4,100 per vehicle; but that would generate different yardsticks for each measure of willingness to pay. For example, when we adjust the government's measures for more realistic estimates of willingness to pay, we find net losses that would reduce the divisor. The agencies estimate that consumers will also be willing to pay for achieved levels of 56.0 mpg for MY 2025 cars and 40.3 mpg for MY 2025 light trucks. See also "Dealers Fight Mileage Rules," The *Wall Street Journal*, January 28, 2012.We derive a slightly lower estimate of the retail price increase, or $1,900 per vehicle versus the $2,000 per vehicle reported in the article. We derive a slightly lower estimate of $4,100 willingness to pay than the reported $4,400 per vehicle.

[2] See National Research Council, *Assessment of Fuel Economic Technologies for Light-Duty Vehicles* (2011), pages 24-26 and Michael Whinihan, Dean Drake, and David Aldorfer, "Retail Price Equivalent vs. Incremental Cost Multiplier: Theory and Reality," Defour LLC, submitted to the Docket, by the National Automobile Dealers Association, February 2012.

[3] 75 Fed. Reg 25324, 25636 (May 7, 2010)

[4] We also take issue with proposal's underlying direct manufacturing costs, which would be found to be much higher in an earlier review of their Interim Joint Technical Assessment Report. Dean Drake, David Aldorfer, Michael Whinihan, and Thomas Walton, "Using Economic Analysis to Assess the Viability of Post-2016 MY Greenhouse Gas Emission and Fuel Economy Standards for Light Duty Vehicles," Paper #12IDM-0034, Society of Automotive Engineers, Forthcoming.

Finally, there is little evidence to be found in the economic literature for any "energy paradox," or disparity between what auto buyers are willing to pay and what makes sense for them to pay as consumers trying to stay within their household budgets. We find instead that they are reasonably intelligent and well-informed and that they evaluate or "discount" future fuel savings at interest rates reasonably comparable to those they must pay for vehicle loans.

## II. Why the Agencies' Engineering Model Overestimates Willingness to Pay

EPA and NHTSA's engineering model is built on the assumption that consumers would be willing to pay for 100% of the fuel economy gains made possible by fuel efficiency technologies; i.e., that consumers evaluate the desirability of making an investment on the basis of the present discounted value of future energy savings less purchase price and that nothing else matters. This assumption overstates actual, real-world willingness to pay for three fundamental reasons.

It ignores, as former Resources for the Future President, Paul Portney, and his colleagues point out, significant expenses that vehicle manufacturers and their dealers must incur when they have to implement new technologies in the field – expenses that increase the cost and thus reduce the value of any gains in fuel economy.[5]

The engineering models erroneously assume a world of perfect certainty in which all consumers are exactly alike. Richard Newell, now-head of the Energy Information Administration (EIA), observes:

> [T]he problem with this approach is that it does not accurately describe all the issues that can influence energy-efficiency investment decisions. First, the importance of certain factors can vary considerably among purchasers, including the purchaser's discount rate, the investment lifetime, the price of energy, and other costs. For example, it may not make sense for someone purchasing an air conditioner to spend significantly more purchasing an energy-efficient model: there simply may not be adequate opportunity to recoup the investment through energy savings. . . . Second, the technologist's engineering-economic analysis typically does not account for changes over time in the savings that purchasers might enjoy from an extra investment in energy efficiency, which depends on trends and uncertainties in the prices of energy and conservation technologies. When making irreversible investments that can be delayed . . . the presence of this uncertainty can lead to a higher investment-hurdle rate. The magnitude of this 'option-to-wait' effect depends on project-specific factors, such as the degree of energy-price volatility, the degree of uncertainty of the cost of the investment, and how fast energy and conservation technology prices change over time. Finally, there is evidence that energy savings from higher efficiency levels have routinely been overestimated, partly because projections often are based on highly

[5] Paul Portney, Ian Parry, and Winston Harrington, "Reply," *Journal of Economic Perspectives* (Spring 2004), page 274.

> controlled studies that do not necessarily apply to actual, realized savings in a particular situation.[6]

While Newell's commentary focused on the market for home appliances, each of these considerations applies with full force to the market for automotive fuel efficiency. Auto buyers are unique individuals with unique needs and circumstances that make for a wide range of *expected* values for future fuel savings. There is a high degree of uncertainty and thus room for disagreement regarding future trends in fuel prices, future retail prices for new technologies, and how fast innovation is likely to make obsolete their investments in those technologies. And, as the studies we review below demonstrate, NHTSA/EPA's "highly controlled studies" do not in fact apply to "actual, realized savings" that auto buyers can *expect* to achieve in the real-world.

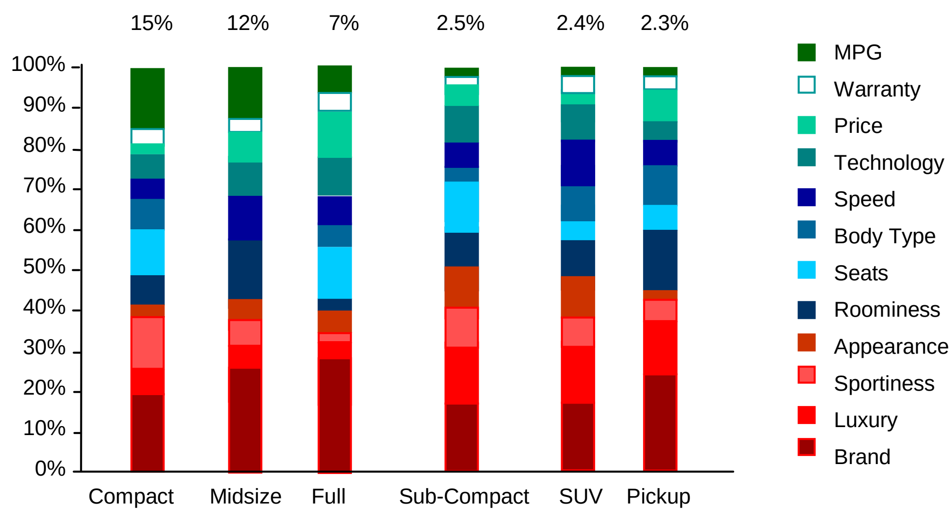
Most importantly, even if the future fuel savings and present costs of those technologies could be projected with perfect certainty to be "cost-effective," NHTSA and EPA fail to consider that buyers may prefer to spend those gains on other vehicle attributes that are even more valuable to them. In this case, forcing them to forego other automotive attributes will make them worse off even if the investment in increased fuel economy shows a positive "net present value" in an accounting sense.

Alternative vehicle attributes include improved carrying capacity, acceleration, ride comfort, mass, and safety. Indeed, Jeremy Anwyl, Chief Executive for Edmunds.com, finds (Figure 1) that in most vehicle segments performance and size (a proxy for safety) are more important to today's auto buyers than fuel economy – and this is with fuel prices running at or above the $3.54 per gallon gasoline projected for MY 2025.[7] What's more, he finds (Figure 2) that the market penetration of the most fuel efficient class of vehicles - hybrid, electric - remains below 3% of total U.S. light duty vehicle sales.[8]

[6] Newell, Richard, "Balancing Policies for Energy Efficiency and Climate Change," *Resources*, Summer 2000, pages 15-16.
[7] Fuel price projection comes from NHTSA, Proposed Regulatory Impact Analysis (November 2011), page 631.
[8] Edmunds.com, "Edmunds CEO Gives Consumers a Voice on CAFE," October 12, 2011 at http://www.edmunds.com/industry-center/commentary/edmunds-ceo-gives-consumers-a-voice-on-cafe.html

Figure 1

Vehicle Attribute Weighting by Segment




Source: Edmunds.com

An engineering estimate of positive net present value or positive "owner lifetime fuel savings," as EPA and NHTSA call it, is a necessary, but not a sufficient condition for the rational consumer to be willing to pay for a vehicle with higher fuel economy. In a budget-constrained world – a world in which affordability is a critical consideration – customers cannot expect to get increased fuel economy without giving up one or more other vehicle attributes. Consumers must choose among all the competing attributes, making sure that they get the greatest value possible given their specific preferences. Spending more on fuel economy means giving up the chance to get still greater value or "utility" from performance and/or "roominess."

Suppose, for example, a new fuel savings technology comes along that could enable a new car buyer to spend (invest) an extra $1,000 to get $200 per year worth of fuel economy savings over a 12-year life of a vehicle. At, say, a 9% auto loan rate, NHTSA's engineering model would find net present discounted value of this annual savings would come to $432 per year, or $1,432 in present discounted fuel savings less the $1,000 expenditure. Suppose further that the same $1,000 could be spent on (invested in) a larger vehicle that will comfortably seat 5 instead of 4 people and hold 4 instead of 3 large suitcases. Typically, the latter vehicles rent for an extra $10 per week or about $500 more per year than the former. The net present discounted value of the latter investment would then be $2,580 or six times that of the payoff from the expenditure on increased fuel economy.

Note that the buyer doesn't have to use a financial calculator or hire a certified public accountant to figure this out. She doesn't even have to put a dollar value on the increased carrying capacity. All she has to do is to ask herself whether she would take the $200 per year in fuel savings or the added comfort and cargo space.

Yet EPA and NHTSA's engineering model would say that she should be willing to pay for the increase in fuel economy because it has a positive net present value. It does, but she can get a lot more for her money from increased roominess and carrying capacity.

In such a situation, mandating an increase in fuel economy imposes what economists call "opportunity costs" on auto buyers - the value of the foregone benefits from expenditures on other vehicle attributes. When, as in this hypothetical example, these foregone benefits exceed the value of a given fuel economy mandate, the increased mandate entails a net consumer welfare loss or reduction in willingness to pay. (Appendix A offers a formal proof of this point.)

To quote, once again, Richard Newell in his study of consumer choice in the market for household appliances:

> Requiring consumers to purchase appliances with a higher level of efficiency based on a simplistic analysis could, in effect, impose extra costs on consumers. *The result might be a higher level of energy efficiency but decreased economic efficiency, because consumers could be forced to bear costs that they had otherwise avoided.*[9]

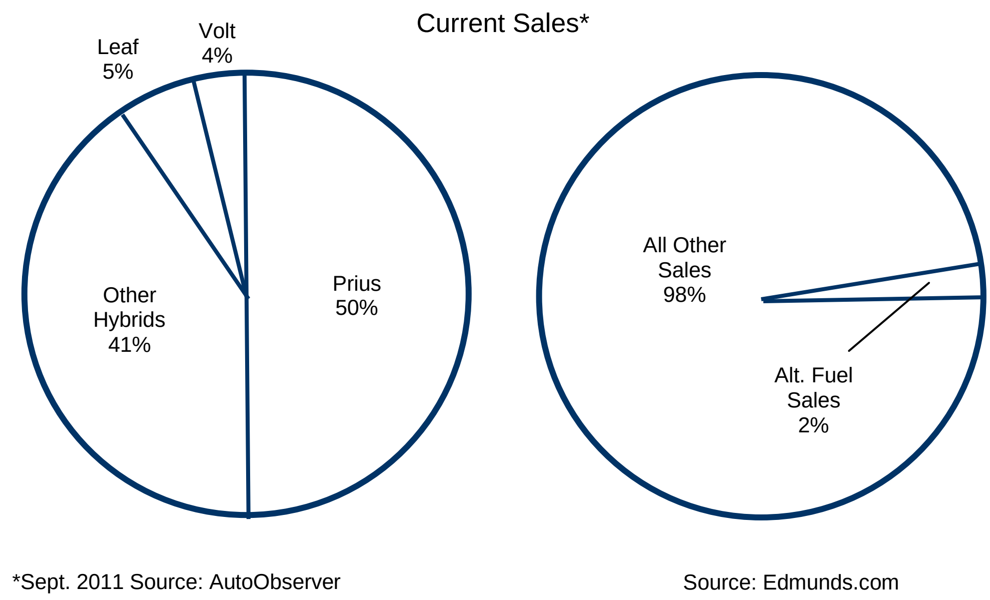
To quote the Congressional Budget Office (CBO):

> Vehicles' current level of fuel efficiency most likely reflects consumers' trade-offs between fuel economy and other characteristics that drivers want, such as vehicle size, horsepower, and safety. *The same technologies that can be used to boost fuel economy* <u>*can be used to hold fuel economy constant*</u> *while increasing the vehicles' weight, size, or power.* . . . Raising CAFE standards would impose costs on both consumers and automobile producers by forcing improvements in fuel economy that car buyers may not want.[10]

That is why real-world auto buyers do not want to spend all of their money on fuel economy and as shown in Figure 2, at $3.54 per gallon gasoline hybrids that achieve 36 to 50 mpg -- well below the mandated level of 56 mpg for passenger cars -- account for no more than 2% of total vehicle sales.[11]

[9] Supra note 6.
[10] *Infra* note 51.
[11] Supra note 7.

Figure 2




Advocates of higher fuel economy standards often point to surveys indicating popular support for increases in the mandate. For example, a *Consumer Reports* survey "found" that 93 percent of those surveyed would be willing to pay for a standard of 55 mpg or more. But as Jeremy Anwyl, CEO of Edmunds.com, points out, there are at least three reasons why this estimate is biased dramatically upward.[12]

- Like the government's engineering analysis, such surveys do not ask consumers to "make tradeoffs" between fuel economy and other attributes that are much more important to them, as shown in Figure 1.
- What Anwyl calls "social desirability bias" or the tendency of respondents to provide answers that will be "socially acceptable" - that will give the answers the respondent thinks will please the pollster and "help the environment." Possibly the best examples of this bias are the surveys that "show" up to 70% of European air travelers will voluntarily pay for carbon "offsets," versus the 2% to 7% that have opted to do so when given the chance.[13]
- The way in which questions are worded often biases respondents towards answers the pollster wants to see. This is especially apparent in the polls commissioned by supporters of one party or political candidate vs. another. Politicians sometimes dismiss these reasons, pointing out that, on balance, political polls do a pretty good job of predicting election outcomes. But it is one thing to predict election outcomes involving one candidate against another and quite something else to determine

[12] Jeremy Anwyl, "Take Polls With a Grain of Salt," (10/28/2011) at http://www.edmunds.com/industry-center/commentary/take-polls-with-a-grain-of-salt.html
[13] Eke Eijgelaar, "Voluntary Carbon Offsets: A Solution for Reducing Tourism Emissions? Assessment of Communications Aspects and Mitigation Potential," *European Journal of Transport and Infrastructure Research* (ISSN 1567-7141), June 1, 2011, pp 286-287.

willingness to pay for something with so many tradeoffs as fuel economy. And the surveys seldom confront respondents with the true costs of the standards: they are often left to assume "Detroit" or "Tokyo" will foot the bill or, as the agencies erroneously assume, the full costs of the standards will not be passed on to the customer.

The European experience with diesels provides a striking illustration of the real-world tradeoff between fuel economy and size. Lee Schipper et al found that while diesel cars and trucks sold in Germany in 2006 "had a technical advantage of 15% less $CO_2$ emissions per kilometer than gasoline-powered cars and trucks, the purchase of larger diesel vehicles virtually offset all of this advantage." He noted that some, but not all of this difference could be explained by self-selection, with people already planning to buy larger cars choosing diesels.[14] Whatever the exact breakdown, this example shows that even if, in the presence of heavy subsidies and incentives, consumers are willing to purchase vehicles with technologies providing potential fuel economy increases of 25% and more, and with carbon dioxide emissions reductions of 15% and more, they might still prefer to spend most of the money on improving performance and increasing size, instead of on reducing fuel consumption. Denying them this opportunity imposes costs on them that must be factored into any assessment of willingness to pay.

The Toyota Prius family of compact hybrid cars may offer yet another example. The 2010 Prius was able to achieve a gain of 4 mpg over the 2009 model or from 46 mpg to 50 mpg. However, the recently introduced upscale, larger and roomier MY 2012 Prius V gets an EPA combined 42 mpg. Industry analysts are worried that, rather than increasing overall Toyota sales, the Prius V might instead "cannibalize" sales of the standard Prius.[15] If sales of the Prius V capture, say, just 25% of existing Prius sales, the newer hybrid technology will lower Toyota's overall corporate average fuel economy rating for mid-size hybrid vehicles, from 50 mpg to 47.73 mpg (using harmonic averaging) – for a net gain of just 1.73 mpg vs. the 4 mpg increase the agencies' Volpe engineering model would predict. If instead, the new Prius V captures 50% of existing Prius sales, the new average mpg for the compact class of Prius hybrid vehicles will *fall* to 45.65 miles per gallon, a *decline* of 0.35 mpg.

Increased size and mass (and the concomitant increase in occupant safety) is not the only alternative available to auto buyers. Consumers may also prefer to take some or all of the improved hybrid fuel efficiency gains as improved performance. In that case, as Assistant Secretary of Energy for Domestic and International Affairs and former Brookings Senior Fellow, David Sandalwood, observed, "The fact that an engine is a hybrid does not necessarily mean it will achieve substantial fuel savings." This is because, in his words, "hybrid technology can also be used to improve acceleration," so

[14] The authors also found that higher mpg diesel cars were driven 40-100% more than gasoline-powered cars, but some of this was attributable to lower diesel fuel prices See, L. Schipper, Marie-Lilliu, and L. Fulton, "Diesels in Europe: Analysis of Characteristics, Usage Patterns, Energy Savings and CO2 Emission Implications," *Journal of Transport Economics and Policy*, 2002, 36(20), pp 305-340

[15] The Detroit Bureau, "Toyota Already Planning Production Increase of New Toyota V Hybrid," June 8, 2011, at http://www.thedetroitbureau.com/2011/06/toyota-already-planning-production-increase-of-new-prius-v-hybrid/

that the net result could be only "somewhat better fuel efficiency than the standard internal combustion engines."[16]

In short, even much-heralded hybrid and advanced diesel technologies – technologies that constitute more than 20% of vehicle sales in the agencies' projections for MY 2025 -- will not increase fuel economy appreciably if consumers choose to invest the potential gains in other vehicle attributes that they prefer.

## III. Willingness to Pay: Revealed Preference vs. Financial Engineering

NHTSA appears to have addressed this issue by conducting a sensitivity study in which they assume consumers will be willing to pay for 50% of their 15.5 mpg mandated fuel economy increase to 49.6 mpg in MY 2025 from the MY 2016 baseline. They find that the standards would still be a bargain.[17]

But 50% is far too high. A realistic estimate that relies on consumers' revealed preferences (on the choices they make) is much closer to 25% -- the assumption used to derive the initial estimate of a loss of $1,400 per vehicle for MY 2025 standards.[18] A 2008 study by MIT's Laboratory for Energy and the Environment provided the basis for subsequent National Research Council estimates of cost-effective fuel efficiency technologies, found that U.S. consumers were willing to pay for <u>none</u> of the fuel economy improvements that U.S. manufacturers offered them, while European auto buyers were willing to pay for just 50% of the gains that could be realized from similar technologies.[19] Their study was for the years 1995-2006 when U.S. regular unleaded gasoline sold for an average $2.07 per gallon (in 2009 dollars) and European premium unleaded fuel prices sold for an average of $5.15 per gallon (median of $5.30 per gallon). The actual relevant fuel cost in Europe, of course, is much higher when applicable engine displacement taxes are factored in.

It can be conservatively assumed that a $5.50 per gallon average price in Europe is the level of fuel prices at which auto buyers will be willing to pay for 50% of any potential fuel economy improvements, and $2.10 per gallon is the price at which they are willing to pay nothing. This yields a midpoint estimate of about $3.80 per gallon as the point at which auto buyers are willing to spend 25% of any increase in fuel efficiency on fuel economy. NHTSA uses a gasoline price of $3.54 per gallon as their projection for MY 2025, so an estimate of 25% willingness to pay at $3.54 gasoline is somewhat overstated.

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[16] David Sandalow*, Freedom from Oil: How the Next President Can End the United States' Oil Addiction*, Brookings (2008).

[17] NHTSA, Proposed Regulatory Impact Analysis, (November 2011), pages 697-723. , and 703 (web version). They elaborate on these points at pages 697-723 and 598-600.

[18] In "Laboratory for Energy and the Environment, On the Road in 2035: Reducing Transportation's Petroleum Consumption and GHG Emissions, Massachusetts Institute of Technology, July 2008, pages 61 and 156-157", the MIT researchers state that in the U.S., there is 0% willingness to pay at $2.07 per gallon gasoline and Europeans have a 50% willingness to pay at $5.50 per gallon. The midpoint fuel price is $3.80 and the midpoint willingness to pay is 25%.

[19] Laboratory for Energy and the Environment, On the Road in 2035: Reducing Transportation's Petroleum Consumption and GHG Emissions, Massachusetts Institute of Technology, July 2008, pages 61 and 156-157.

## IV. Reality Check: What Does the Literature Say?

This paper's estimate of a net negative consumer willingness to pay for a fuel economy increase of 15.5 mpg, derived as it is from consumer-driven corrections to NHTSA's estimates of willingness to pay and retail price markups for the requisite fuel efficiency technologies, is quite conservative compared to those of published research. This includes research at EIA, the agency Congress established to provide independent, "policy neutral" estimates of the impacts of alternative governmental policies, including the corporate average fuel economy standards. [20] In a special study included in its 2011 Annual Energy Outlook,[21] the EIA concluded that a CAFE standard of 46.1 mpg - 12 mpg above the baseline 2016 MY level and 3.5 mpg lower than the proposed 2025 mandate - would result in an 8% loss in new vehicle sales in 2025 - a loss that would not materialize if auto buyers were willing to pay for the increased fuel economy.

Although the EIA does not provide specific estimates of willingness to pay and net lifetime owner vehicles fuel savings (losses), the 8% unit sales loss is consistent with a net negative willingness to pay of about $2,200 per vehicle – or 8% of today's average vehicle transactions price of $28,000 (assuming the a consensus unitary industry vehicle price elasticity of -1).[22] In other words, the EIA's estimate of unit sales losses corresponding to an 8 mpg increase to 46.1 mpg suggests that vehicle prices will rise by $2,200 more than the value of the resulting fuel savings.

Yet another estimate of willingness to pay, starting with the same MY 2016 baseline, can be inferred from a 2008 study by NERA Economic Consulting for the Alliance of Automobile Manufacturers, which found that auto buyers are willing to pay $49,725 for each reduction of $1 per mile in vehicle operating expenses.[23] The 49.6 mpg level under the Preferred Alternative is a 15.5 mpg increase over the baseline of 34.1 mpg in 2017. Applying the NERA estimated willingness to pay of $49,725 for each $1 per mile reduction in vehicle operating costs yields a willingness to pay of $1,600 per vehicle relative to MY 2016.[24] Subtracting out our revised $3,000 per vehicle estimate of retail price increase yields a net consumer willingness to pay for NPV fuel economy gains equal to a negative $1,400 per vehicle.

A third, qualitative estimate, but one that gets at the issue of marginal vs. average losses in willingness to pay, is to be found in a Resources for the Future (RFF) November 2010 study co-authored by David Evans of the EPA. It finds:

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[20] http://useconomy.about.com/od/governmentagencies/p/DOE_EIA.htm

[21] Energy Information Administration, "Increasing light-duty vehicle greenhouse gas and fuel economy standards for model years 2017 to 2025," (2011).

[22] NHTSA, Proposed Regulatory Impact Analysis (November 2011), page 600.

[23] NERA Economic Consulting, *Evaluation of NHTSA's Benefit-Cost Analysis of 2011-2015 CAFE Standards*, Alliance of Automobile Manufacturers (2008), page A-7. The math is: first divide $3.54 per gallon by 34.1 miles per gallon to yield $0.10381 per mile at 34.1 mpg. Next divide $3.54 per gallon by 49 .6 mpg to yield $0.071371 per mile at 49.6 mpg. Then multiply the difference, or $.03244 by $49,725, the value of each $1 per mile reduction in operating costs, which yields $1600 per vehicle willingness to pay, which compared to the price increase of $3000 per vehicle, yields a net consumer welfare loss of $1400 per vehicle, rounded to the nearest $100.

> [U]sing standards to cut fuel use by 5 percent under a standard value for $CO_2$ damages is warranted only if consumers fail to internalize 44 percent of the savings from fuel economy. In fact recent rulings that rapidly ramp up the corporate average fuel economy CAFE standards are not supported on welfare grounds, even under our bounding case for market failures. . . . In our bounding case for these failures, a standard that cut fuel use by 8.9 percent would be optimal, though potential welfare gains are only about a third of those for the fuel tax.[25]

Dr. Evans et. al. assume a baseline free expression combined fleet fuel economy level of 23 mpg and the 8.9% reduction in fuel consumption equates to 36% of the 25% cut mandated by the 2012- 2016 MY standards relative to that baseline. They find that the marginal net losses in combined consumer and societal welfare – the sum of the values of private and social present discounted lifetime fuel savings less retail price increases[26] - rapidly escalate to a combined *loss* or net cost of $6 per gallon and higher well before required fuel savings approach the 25% reduction that would be achieved under the MY 2016 standards. Going another 13.5 mpg to MY 2025 standards would send these losses into the stratosphere.

Earlier studies by economists at RFF and the CBO also found that raising mandated fuel economy levels just a few mpg above those for which consumers are willing to pay will impose very substantial, exponentially increasing consumer welfare losses as well as societal welfare losses on the broader economy.[27]

For example, the RFF study by Fischer et al concluded:

> The bottom line is that the efficiency rationale for raising fuel economy standards appears to be weak, unless carbon and oil dependency externalities are far greater than mainstream economic estimates, or consumers perceive only about a third of the fuel-saving benefits from improved fuel economy.[28]

The CBO concluded:

> Increasing CAFE standards or the gasoline tax would impose costs on both producers and consumers of vehicles and gasoline – direct costs that are estimated by CBO's modeling. Would those costs be justified by the accompanying benefits? Unless current estimates of the benefits of reducing gasoline

[25] Ian Parry, David Evans, and Wallace Oates, "Are Energy Efficiency Standards Justified?' Resources for the Future Discussion Paper 10-59, November 23, 2010, page 19 at http://www.rff.org/documents/RFF-DP-10-59.pdf

[26] The authors do not separate out consumer from societal welfare losses, so that the consumer welfare losses would be lower, but still positive and quite large.

[27] See, in particular, Carolyn Fischer, Winston Harrington, and Ian Parry, "Should Corporate Average Fuel Economy Standards (CAFE) be Tightened?" *Energy Journal* (2007) at http://www.rff.org/documents/RFF-DP-04-53-REV.pdf, Winston Harrington, Ian Parry, and Margaret Walls, "Automobile Externalities and Policies," *Journal of Economic Literature (2007),* and David Austin and Terry Dinan, "Clearing the Air: The Costs and Consequences of Higher CAFE Standards and Increased Gasoline Taxes," *Journal of Environmental Economics and Management* (2005). *The Journal of Economic Literature* article is a survey of the leading economic studies in the field.

[28] Fischer et al, ibid, at page 3 of the RFF paper.

> consumption are significantly understated, increasing CAFE standards would not pass a benefit-cost test.[29]

Thus far, this report has focused on the amounts that auto buyers would be willing to pay for fuel economy increases, comparing them to the retail price increases that are necessary to achieve those levels. If the retail price increases exceed willingness to pay, as they do in all the cited studies, then the standards are too stringent and will cause a loss of sales and industry employment. Yet another way of getting at willingness to pay is to find the “free expression” level of fuel economy – the level that unconstrained auto buyers would choose if there were no fuel economy standards. How does the government’s projection of a 49.6 mpg level for combined car and light truck sales (56.0 mpg for cars and 40.3 mpg for light trucks) compare to the free expression level?

The NRC found in its 2010 study that if consumers were willing to pay for 50% of potential fuel economy improvements the government could achieve a level of just 40 mpg for combined cars and light trucks in MY 2035.[30] Of course, the 50% willingness to pay is more than double the level found in the MIT study cited above, and the learning curve effect means that 2025 technologies will cost more than those in 2035.

Another, more current and more realistic estimate is provided by the EIA in its *Annual Energy Outlook* for 2011. As shown in Figure 3 below, the agency projects unconstrained or free expression levels of fuel economy for MY 2025 at 35.3 mpg for $3.54 gasoline (40.0 mpg for cars and 29.6 mpg for light trucks). It also finds that at $5.12 per gallon - its highest fuel price scenario for 2025 - the combined new vehicle fleet would attain 36.8 mpg with cars at 41.1 mpg and light trucks at 30.4 mpg, well below the levels of standards mandated by NHTSA and EPA.[31]

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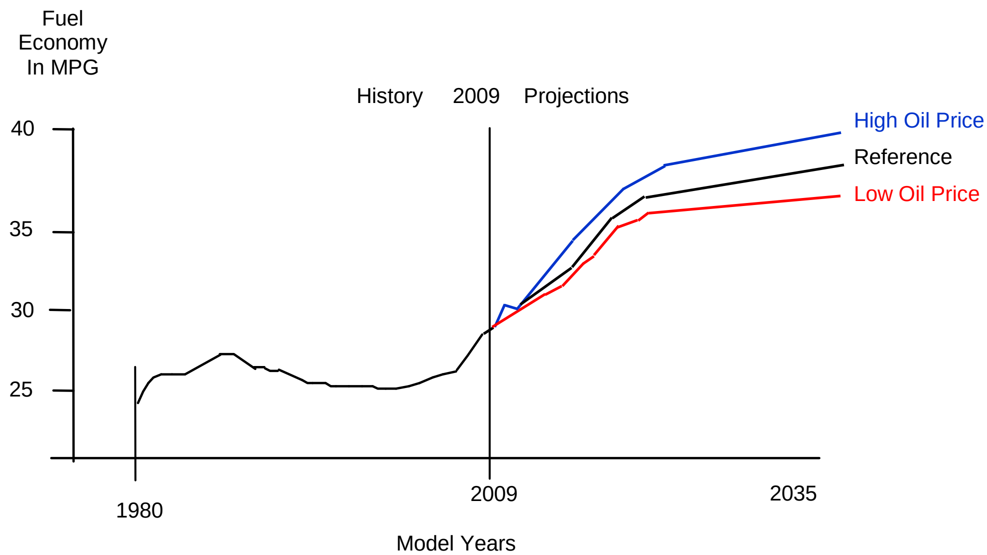
[29] Congressional Budget Office, *Fuel Economy Standards Versus a Gasoline Tax*, March 9, 2004, pages 3 to 4.
[30] NRC, *America’s Energy Future* (2010), Tables 4.3 and 4.4.
[31] EIA, *Annual Energy Outlook 2011*, page 71.

Figure 3

CAFE Standards Boost Fuel Economy

Average Fuel Economy of New Light-Duty Vehicles




Source: Energy Information Administration, Annual Energy Outlook, 2011, Page 71

Yet a ninth reality check, or alternative way of estimating consumer willingness to pay for fuel economy increases, is provided by the European responsiveness to much higher fuel prices when there were no fuel economy regulations. Estimates of willingness to pay at higher fuel prices can be derived from European levels of fuel economy that existed in the late 1990s and early 2000s, represent free expression levels that their consumers would be willing to pay for. Customer demand for passenger cars never exceeded 40 mpg – well below the agencies' projection of a 56 mpg level in 2025 - with $7 and $8 per gallon gasoline, with heavy engine displacement taxes, and with substantial subsidies for diesel fuel.

*Inexplicably, NTSA and EPA do not account for any of these statistics in their analysis.*

## V. The "Energy Paradox" and the Government's Engineering Analysis

EPA and NHTSA suggest that consumer myopia, and not any errors in their analysis, explains what they call the "Energy Paradox," or why today's auto buyers would be "hesitant" to flood dealer showrooms with purchase orders for vehicles that achieve 49.6 mpg on average and provide, by their reckoning, more than $4,000 worth of fuel savings net of retail price increases. They cite economic literature that, in their view, confirms this myopia and explains why their mandate is necessary.

They nonetheless ask for comments on "why would potential buyers of new vehicles hesitate to make investments in vehicles with higher fuel economy that would produce the substantial economic returns [that they estimate]," and "why [if the returns are so high] stricter CAFE standards should be necessary to increase the fuel economy of new cars and light trucks?" They add, "If this [hesitation] is widespread, the average fuel economy of their entire new vehicle fleet could remain below the level that potential buyers demand and are willing to pay for."

The first point to be made is that whether or not auto buyers know what they are doing, their choices do, in the final analysis, actually determine the real demand for new cars and light trucks in the marketplace. When, for whatever reason, their willingness to pay for increased fuel economy falls short of the increased retail vehicle price necessary to attain that level, industry sales losses necessarily ensue, as the EIA analysis found.[32] This is so even if better informed and more intelligent auto buyers would be arguably willing to pay for 100% of the "cost-effective" fuel efficiency gains assumed in the agencies' mathematical model.

What's more, if the mainstream studies that we cite are correct, the standards cannot be justified on benefit-cost grounds even if the supposed consumer undervaluations are corrected using the most liberal, "upper bound" assumptions and "upper bound" assumptions regarding externality costs of climate change and energy security.[33] There is no basis for increasing the standard – neither on the consumers' behalf nor on the public's behalf. The proposed increase will make everyone worse off.

Nonetheless, we comment here on the 2010 study the EPA commissioned by its consultant, David Greene,[34] who found a wide divergence of implicit consumer discount rates that consumers use in evaluating the gains from fuel economy improvements and that he could not explain by differences in modeling methodologies or data. Greene reviewed 25 studies, finding "[w]ith a very few exceptions, no obvious flaws in the methods or data used by these studies."[35] More importantly, he found a general or average undervaluation of future fuel economy gains (myopia) across these studies – a finding that he emphasized in a similar study dated one month earlier.[36]

In fact, the studies that Greene reviews contain at least seven major and widespread errors and oversights, which, when accounted for, suggest that auto buyers are reasonably rational – that, in their comparison of automobile fuel economy stickers to purchase price they use implicit discount rates that, on average, are reasonably close to the rates they pay on auto loans.

The most significant and widespread error – the very same error that is inherent to the agencies' model of consumer choice – is that most of the studies and surveys fail to account for tradeoffs between fuel economy and other vehicle attributes of value to consumers – what the studies call "fixed effects."[37] This error is especially widespread

[32] See text accompanying *supra* note 17.
[33] See text accompanying *supra* notes 22 - 26.
[34] And that was peer-reviewed by RTI, the author of the EPA's study of Indirect Cost Multipliers.
[35] David Greene, "How Consumers Value Fuel Economy: A Literature Review," United States Environmental Protection Agency, March 2010. See, e.g., Greene's finding # 2 on page 55 of the EPA report
[36] "Why the Market for Passenger Cars Generally Undervalues Fuel Economy," Joint Transportation Research Centre, Paris, February 18-19, 2010.
[37] EPA and NHTSA argue that they have taken account of these tradeoffs by adding in what they consider to be the costs necessary to maintain utility at base year 2017 levels. But that is not the question. The question concerns the tradeoffs going forward -- in MY 2025-- between increased fuel economy and increases in performance, mass, and safety that can be derived from the assumed future gains in fuel

in the models finding myopia or irrational consumer *under*valuation of fuel economy gains. Most of the studies of consumer valuation were done during periods of very low fuel prices and of clearly binding fuel economy constraints. Surveys finding that consumers irrationally undervalue fuel economy increases during these periods are invalid because constrained consumers already have more fuel economy than what they want and are thus inclined to spend most, if not all of their money on other vehicle attributes (See Appendix A). Dr. Greene himself makes this pervasive flaw in his study of rebound effects – a study the PRIA also references and relies on.[38]

As Busse et al point out,[39] this problem is especially severe in cross section models and surveys, because unless the tradeoffs between fuel economy and other vehicle attributes are taken into account and well specified, consumer willingness to pay more for higher performing and larger but lower mpg vehicles can cause a spurious positive relationship between fuel cost and vehicle purchase price. The higher fuel cost of higher performing vehicles results from their higher utility and not from an irrational desire to pay more for cars that cost more to operate. Models that fail to take this into account bias the implied consumer discount rate upward, leading to findings of consumer myopia (undervaluation) where it does not exist.

A second pervasive problem that Greene also identifies, which NHTSA and EPA ignore, is the assumption in nearly all of the 25 studies that expected future fuel price movements follow a random walk, with consumers always assumed to project future fuel prices to be equal to present prices regardless of any price shocks. During periods of energy price shocks, such an assumption biases the estimates of consumer valuations upwards (because they are in fact reacting to higher future expected benefits than what the model is assuming) and thus the implied discount rates downward (and conversely during periods of unexpected, sharp declines in fuel prices such as was true in the mid-1980s). This no doubt accounts for much of the variation in estimates Greene find in these studies.

A third persistent and serious error across most of the studies is the use of aggregate vehicle classes, or even the entire light duty vehicle market to test the impact of fuel price and fuel cost changes. As Busse et al and Spiller[40] observe, failure to disaggregate to the individual consumer level can easily bias the estimates of implied consumer discount rates upward because it violates the critical condition of ceteris paribus or "all else equal," failing to allow consumers to switch within vehicle segments and classes in

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efficiency? If buyers only want to spend 25% of the gains on fuel economy, forcing them to spend more than that amount will impose opportunity costs on them and these costs will exceed the benefits of putting more than that 25% into fuel economy gains.

[38] David Greene, "Rebound 2007: Analysis of light-duty vehicle travel statistics," *Energy Policy*, forthcoming, page 7.

[39] Meghan Busse, Christopher Knittel, and Florian Zettlemeyer, "Pain at the Pump: The Effect of Gasoline Prices on New and Used Automobile Markets," University of California Energy Institute, UC Davis Institute of Transportation Studies and National Bureau of Economic Research (September 2011).

[40] Elisheba Spiller, "Household Vehicle Bundle Choices and Gasoline Demand," Resources for the Future and Duke University, January and July 2011 at http://emf.stanford.edu/files/docs/322/SPILLER.pdf and http://fds.duke.edu/db/aas/Economics/phd/elisheba.spiller/files/Elisheba%20Spiller%20Job%20Market%20Paper.pdf (two separate papers).

response to changes in fuel prices and vehicle fuel economy levels.[41]

Fourth, Busse et al also utilize a realistic assessment of odometer readings and remaining vehicle useful life, unlike nearly all of the other studies. In their preliminary study, Salle et al also adjusted for odometer readings and useful vehicle life on an individual basis, finding that any failure to do so biases the estimates of consumer undervaluation downward by a "dramatic" amount.[42]

Fifth, nearly all of the studies ignore what Spiller calls the effect of "bundling." She notes that if a household owns more than one vehicle, as 57% of them do, [43] an "increase in gasoline prices would presumably result in a shift from [say the lower mpg] SUV to the [higher mpg] car. However, if these two vehicles were treated as independent [as is most often the case], then a researcher may [erroneously] interpret the increase in the car's VMT as a household that is insensitive to gasoline price changes," biasing her estimate towards undervaluation and myopia.[44]

A sixth shortcoming of many of the models Dr. Greene missed is their assumption of identical auto buyer evaluations of future fuel economy benefits. As we noted in the above discussion of the methodological shortcomings of the NHTSA's engineering, at any point in time there is a wide range of consumer estimates of future fuel prices, future fuel economy technology advances that could obsolete their present purchase, vehicle driving needs, and present and expected future discount rates – all of which result in differing but rational projections of the value of fuel savings on prospective vehicle purchases.[45] Cornell economists, Antonio Bento and Kevin Roth, together with RFF economist, Shanjun Li, found that an assumption of identical preferences and expectations biased the estimate of consumer rationality towards myopia and that use of models that assume varying estimates of future fuel economy benefits resulted in estimates of willingness to pay much closer to rational levels.[46]

Seventh, most of the studies in Greene's review suffer from what Busse et al characterize as "inflexible specification," a bias that results from misspecification of key variables such as discount rates and odometer readings. They note:

> In addressing the question of myopia, researchers face a choice. The theoretical object to which customers should be responding is the present discounted value of the expected future cost for the particular car at hand. Creating this variable means having data on (or making assumptions about) how many miles the owner will drive in the future, the miles per gallon of a particular car, the driver's expectation about future gasoline prices, and the discount rate. Having constructed this variable, a researcher can then estimate a structural parameter that measures the extent of consumer myopia. . . . The [problem with this approach] is

[41] Busse et al at page 20; Spiller at page 3.
[42] James Sallee, Sarah West, and Wei Fan, "The Effect of Gasoline Prices on the Demand for Fuel Economy in Used Vehicles: Empirical Evidence and Policy Implications," May 24, 2011, funded by the Energy Initiative at the University of Chicago and by the Keck Foundation of Macalister College.
[43] U.S. Bureau of the Census, American Community Survey, Table DP-4, 2009.
[44] Spiller, second reference, page 4.
[45] See text accompanying *supra* note 5.
[46] Antonio Bento, Kevin Roth, and Shanjun Li, "Is There an Energy Paradox in Fuel Economy? A note on the Role of Consumer Heterogeneity and Sorting Bias," Resources for the Future, November 2010.

> that the specific assumptions that the researcher has made are 'baked into' the data, and thereby into the results. . . . Furthermore, insofar as these assumptions are not correct, attenuation bias will bias the results towards myopia.[47]

When Busse et al adjusted their own model to allow for consumer tradeoffs between fuel economy and other vehicle attributes, and when they corrected for most of the above common errors in the models reviewed by Dr. Greene, they found consumers valued fuel economy improvements at reasonably rational levels of discount rates. In particular, they conclude:

> We find *little evidence* that consumers "*undervalue*" future gasoline costs when purchasing cars. The implied discount rates we calculate correspond reasonably closely to interest rates that customers pay when they finance their car purchases.[48]

They found that the most reliable estimates of the discount rates that consumers use to evaluate fuel economy gains are to be derived from studies comparing movements in new and, especially, used vehicle prices to movements in fuel prices. These studies generally find discount rates that closely approximate auto loan rates – the rational level of evaluation. The conclusion of the first such study by George Daly and Thomas Mayor, not reviewed by Dr. Greene, is, in our view, most instructive. Daly and Mayor found:

> In the 1970s many policymakers believed that consumers could not be relied upon to make rational judgments about energy consumption. Symptomatic of this view were the arguments . . . that consumers were inherently wasteful in the use of energy, that they were psychologically unable to give up large automobiles, and that such policies as mandatory efficiency standards for appliances and automobiles were the only way to prevent excessive reliance on imported fuel. The findings of this study clearly do not support these arguments. On the contrary, evidence from used car markets suggests that information possessed by consumers and utilized in their decision making is comparable with that possessed by informed policymakers.[49]

The question is not whether automotive markets are perfectly rational in the sense that every buyer always makes decision that are aligned with his or her self-interest. Rather, it is whether on balance, there is reason to believe that buyers refusal of fuel economy improvements reflect anything other than consumer preferences for other more valuable vehicle attributes.

As Paul Portney concluded with his RFF colleagues in the leading survey journal of mainstream economics:

> *Perhaps it is not that consumers misperceive or overly discount fuel-saving benefits, but rather that engineering studies underestimate the true economic costs of actually adopting fuel-saving technologies.* The true economic cost is probably larger than the engineering cost estimates . . . for two reasons. First, it

[47] Busse et al, page 6.
[48] Ibid, page 2 (emphasis added).
[49] George G. Daly and Thomas H. Mayor, "*Reason and Rationality during Energy Crises*," Journal of Political Economy (February 1983), page 180 (emphasis added).

> ignores the possible opportunity cost of not using fuel saving technologies for other vehicle enhancements. That is, by forcing automakers to apply their technical expertise to more fuel-efficient engines, tighter CAFE standards could mean fewer of the improvements to which consumers have responded enthusiastically in the past – including such things as enhanced acceleration, towing capacity and so on. It is the implicit value of these foregone improvements that ought to be compared with the fuel economy savings that tighter CAFE standards would bring.[50]

Finally, CBO, in a study commissioned by the U.S. Senate in 2002, noted that many proponents of increased fuel economy standards argue that the market for fuel economy is inefficient because consumers either "lack information about vehicles' fuel efficiency (*in other words, they do not know what's best for them*) or that producers lack an incentive to respond to consumers' preferences for fuel efficiency." The CBO concluded:

> *Most economists do not believe that either assumption is valid.* Vehicles' current level of fuel efficiency most likely reflects consumers' trade-offs between fuel economy and other characteristics that drivers want, such as vehicle size, horsepower, and safety. *The same technologies that can be used to boost fuel economy* can be used to hold fuel economy constant *while increasing the vehicles' weight, size, or power.* Thus, the fact that producers have done the latter rather than the former in recent years suggest that they have responded to buyers' preferences by targeting available technologies toward other features that consumers desire. Raising CAFE standards would impose costs on both consumers and automobile producers by forcing improvements in fuel economy that car buyers may not want.[51]

## VI. Summary and Conclusions

This report clearly demonstrated with multiple examples that willingness to pay for the proposed MY 2025 fuel economy standards falls far short of NHTSA's estimates. These findings are derived from and verified by research at MIT, EIA, NRC, RFF, CBO, and even the EPA. Mainstream research also shows that, contrary to the government's speculation, this differential cannot be explained by "consumer myopia", or any systematic undervaluation of fuel economy gains.

Rather, the differential is explained by a misspecification of NHTSA's engineering/mathematical model of consumer behavior – a model that ignores numerous uncertainties surrounding consumer expectations of future fuel and technology costs and prices, and that denies auto buyers the opportunity to invest potential fuel efficiency technology gains in increased performance, size, and safety. Models that fail to take account of these factors not only overestimate the ability and willingness of prospective purchasers to pay for fuel economy gain, they overstate the regulatory benefits.

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[50] Paul Portney et al, *supra* page 274. The other cost that engineering studies ignore relates to the various expenses manufacturers and their dealers incur when implementing the new technologies in the field.

[51] Congressional Budget Office, "A CBO Study: Reducing Gasoline Consumption: Three Policy Options (November 2002), Chapter 2, page 2. (Emphasis added)

**Appendix A: The "Energy Paradox" and the Rational Consumer**

The NHTSA and EPA Preliminary Regulatory Impact Analysis (PRIA) notes that their estimate of $4,000 per vehicle lifetime or net present value fuel savings for an 49.6 mpg fuel economy level in MY 2025, when gasoline is expected to cost $3.54 per gallon, is inconsistent with the choices of today's vehicle buyers who are willing to pay for no more than 30 mpg for the combined fleet with gasoline prices ranging between $3 and $4 per gallon. They surmise that this disparity, what they call an "energy paradox," can be explained by consumer myopia - by auto buyers' irrational undervaluation of the present discounted value of future fuel savings. They ask for comments on this issue.

Our explanation of the agencies' quandary is quite simple. The inconsistency between what their engineering model predicts and what consumers actually want arises from the agencies' misspecification of their model, based on an erroneous definition of consumer rationality. According to the agencies' definition, rational consumers should be willing to purchase more "fuel-efficient" [they really mean more "fuel economical"] vehicles so long as the present value of the discounted additional energy savings associated with the requisite technologies equals or exceeds their hardware costs.

That is not how rational consumers behave. Improvements in fuel efficiency technology represent either the ability to reduce the amount of fuel required to move a given amount of mass (or achieve a given level of performance) or the ability to move more mass (or increase performance) for a given quantity of fuel consumed. Consumers can choose to spend the same technology advance on any number of attributes besides fuel economy and the (net present discounted) value of each of those other applications can also exceed the cost of the associated hardware in an engineering sense. Thus, the question is not whether the value exceeds the cost for any one application such as increased fuel economy, but rather, of all the applications, which gives consumers their highest value for the money – i.e., which is cost-effective in an economic sense? Indeed, at $3.54 per gallon, as the following analysis demonstrates and as Figure 1 of the text confirms, spending fuel efficiency technology advances on fuel economy increases is likely to be near the bottom of their list.

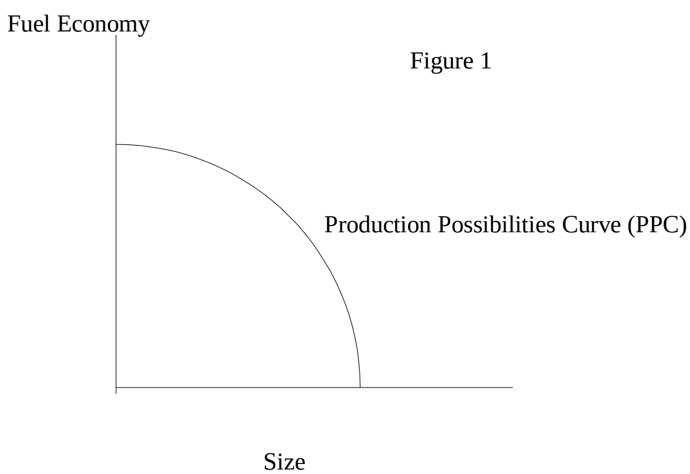
Indeed, because the current fuel economy standard is binding, it is very unlikely that increases in fuel economy can be achieved without substantially increasing the consumer and producer welfare losses (negative profits) associated with forcing consumers to spend the money on something they do not want.

The following figures illustrate the economic "postulates" that underlie consumer rationality. They provide the answer to the energy paradox, showing how fuel economy technologies can be "cost-effective" in a narrow engineering sense (with present discounted fuel savings equaling or exceeding the retail price equivalent for the increased hardware costs), yet irrational in an economic sense. We begin the discussion by first assuming that there are no restraints on consumer choice – no fuel economy or any other standards that limit what consumers can buy.

The economist's world is a world of tradeoffs, where at any point in time producing more of one thing, such as fuel economy cannot be achieved without producing less of something else, such as vehicle size. Figure 1 below assumes that there are two attributes of value to consumers, fuel economy and "size."[52] The curve labeled "production possibilities curve" or "PPC" illustrates a hypothetical set of maximum feasible combinations of these two attributes. For any point along the x axis – that is for any given quantity of vehicle size – this curve shows the maximum feasible level of fuel economy that could be achieved with that size of vehicle. Alternatively, for any point along the y axis – for any given level of fuel economy, it shows the "largest" possible vehicle that might be produced and sold.

Note that, consistent with practical reality, getting more fuel economy and moving in the northern direction, requires that vehicles be "smaller," a move in the western direction. Alternatively, a move in the eastward direction towards "larger" vehicles requires that fuel economy must decline, a move southward.[53] Note, also, that the production possibilities curve is just another word for one level of fuel efficiency technology and that the technology can be applied to various combinations of fuel economy and size. Note, finally, this level of fuel efficiency is the level that is provided in a well functioning, fully competitive market. Manufacturers that fail to provide this level simply are not able to survive amidst such competition.

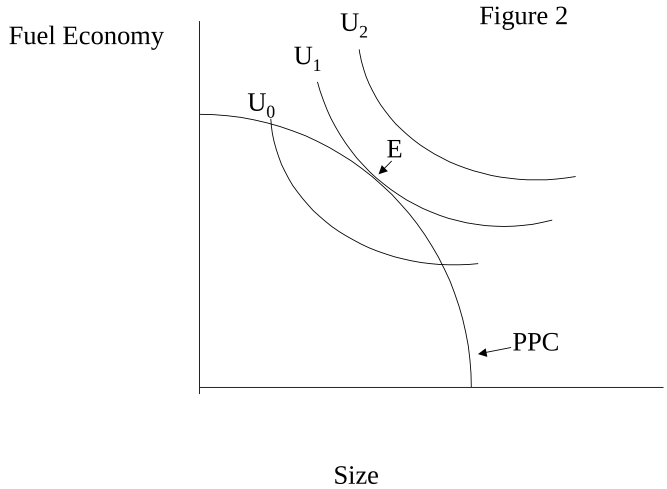
Figure 1




[52] Of course, in the real world consumers value many other attributes, including performance (0 to 60 acceleration time), safety, comfort, towing capacity, and so on. In this two dimensional layout, we can think of size as a proxy for all those other vehicle attributes.
[53] Note that the economists' law of increasing marginal costs of production implies the concave shape of the production possibilities curve. In this context, this law implies that for each additional unit of fuel economy, the producer, and ultimately the consumer, must give up larger and larger amounts of size and vice versa.

Economists also view consumers as being willing to exchange one good for another in varying proportions, as illustrated in Figure 2 by a series of isoutility curves now superimposed on Figure 1.[54] Each isoutility curve represents a constant level of consumer satisfaction. The greater the northeasterly distance from the origin the greater is the constant level of utility, so that $U_2$ represents the highest and $U_0$ the lowest level of constant utility or satisfaction.[55]

Figure 2




The consumers' optimum is reached where they can achieve the highest level of utility consistent with the feasible production set or production possibilities curve (PPC) as indicated by point E in Figure 2. This is the point where the additional utility or satisfaction obtained from spending a dollar on fuel economy just equals the additional utility derived from spending a dollar on size. Economists call this concept the "equal marginal principle" and it is a <u>fundamental</u> principle underlying their analysis of consumer and producer behavior. To quote MIT Professor Robert Pindyck and University of California Professor Daniel Rubinfeld:

> "Only when the consumer has satisfied **the equal marginal principle** – i.e., *has equalized the marginal utility per dollar or expenditure across all goods* – will she have maximized utility."[56] (Boldface and italics in original.)

Of course, this is the economists' operational definition of rationality, as contained in every basic text. In the present context, this principle requires that the added value or utility per each dollar spent be the same for all vehicle attributes.

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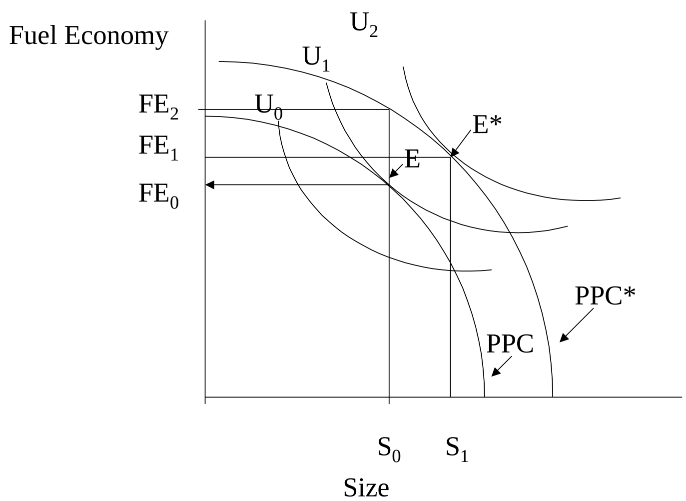
[54] For simplicity, we assume an aggregate consumer welfare function.
[55] The convex shape of each curve reflects the fact that consumers are willing to give up less and less "size" for increasing amounts of fuel economy and vice versa (what economists call diminishing marginal utility).
[56] Robert S. Pindyck and Daniel L. Rubinfeld, Microeconomics, (2001), p. 91.

Now suppose there is an outward shift in the production possibilities curve from PPC to PPC* – i.e., suppose there is an increase in the fuel efficiency technology applicable to cars and light trucks. Because consumers can spend improvements in fuel efficiency technology on either increased fuel economy or on size (a proxy for all other attributes of value), the production possibilities curve shifts outward in every direction.

Figure 3 shows the original hypothetical and unconstrained consumer equilibrium at point E, together with the new equilibrium at point E,* a point at which both fuel economy and "size" have increased as a result of the outward shift in the production possibilities curve. Note that in this hypothetical illustration the rightward or eastward increase in size from $S_0$ to $S_1$ is substantially greater than the upward or northward increase in fuel economy from $FE_0$ to $FE_1$. This is drawn this way because "size" is really a proxy for numerous other attributes besides fuel economy.

Figure 3




The answer to the agencies' "energy paradox" is that, contrary to their engineering model, rational, utility-maximizing and fully informed auto buyers will not be willing to spend all of the potential increase in fuel efficiency on increased fuel economy. This is so even though we are assuming that the net present value of the fuel economy savings from the new technology equals or exceeds the cost of the hardware (which has to be true for the new PPC to represent a maximum feasible set).

In other words, assume that the agencies' engineering analysis is correct and that $FE_2$ is the level of fleet average fuel economy in MY 2025, or 49.6 miles per gallon. Assume further that, as in the agencies' engineering analysis, $FE_0$ is the baseline level of 34.1 mpg in MY 2016. The 13.5-mpg increase - the vertical difference between $FE_2$ and $FE_0$ is the increase *if* consumers were willing to pay for 100% of the potential 13.5 mpg increase. It is "cost-effective" in the narrowly conceived engineering sense – in the sense that the net present value of spending all the money on fuel economy would be positive. But rational auto buyers are not willing to pay for 100% of the potential fuel economy increase. The 13.5-mpg increase in the fuel economy standard is *not* rational and cost-effective in an economic sense. That is because rational auto buyers will only be willing to pay for an increase to the unconstrained level, $FE_1$, a level that maximizes their utility (that puts them on the highest economically feasible isoutility curve), and which as shown in Figure 3 of the text, the Energy Information Agency estimates to be just 35.3 mpg at $3.54 gasoline in MY 2025.

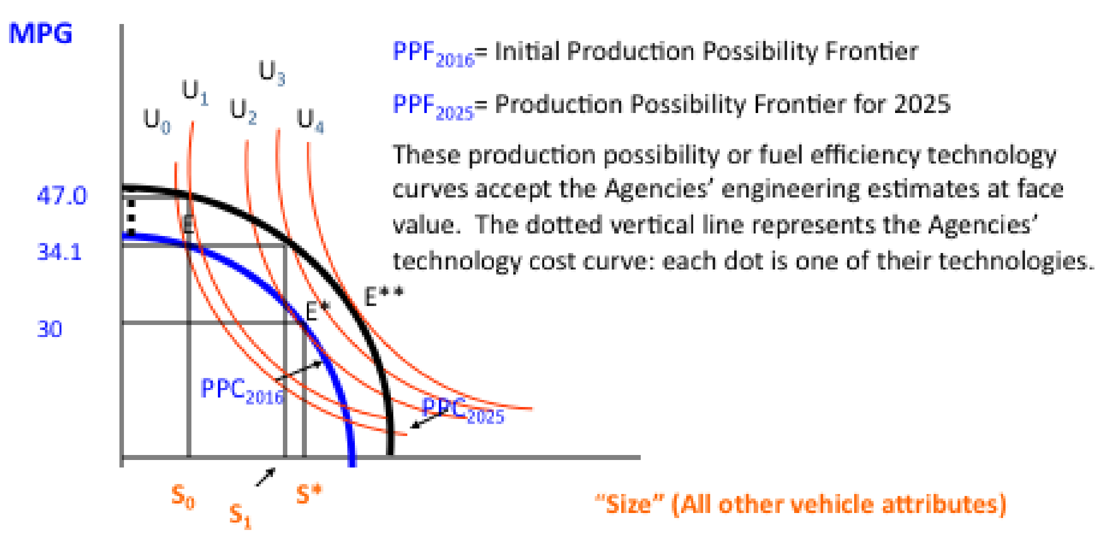
Finally, assume fuel efficiency technology advances as given by $PPC_{2025}$ in Figure 4. Assume further that, initially, in MY 2016, consumers are free to choose the combination of fuel economy and other attributes of value and that, say, 30.0 mpg is the free expression or unconstrained level. Thus, E* (30.0 mpg, S* size) on isoutility curve $U_2$ is the current optimum, or the point that satisfies the "equal marginal principle" for rational consumers.

Assume next that they are forced to purchase the MY 2016 mandate of 34.1 mpg, which puts them at Point E where "Size" is $S_0$ and their utility has been reduced to $U_0$.

In 2025, these still-constrained consumers would maximize their utility or satisfaction at point E,** which would entail an actual reduction in mpg to a level below the 34.1 mpg mandate in 2016. In other words, constrained consumers will be willing to pay to *reduce* fuel economy or mpg to just above the MY 2016 free expression or unconstrained level of 30.0 mpg. Forcing them to take any of the mandated increase in fuel efficiency technology for MY 2025 as fuel economy will result in a loss of consumer welfare; e.g.. it will force them onto a lower utility curve, such as $U_{1,}$ where they must take all of the technology advance in the form of fuel economy.

In other words, while the net present value of the fuel economy gain is positive; it is even greater for the competing increase in vehicle "size." In this case, forcing the consumer to take any of the technology advance as fuel economy gains imposes opportunity costs in terms of the foregone, more valuable increase in "size." Hence, her willingness to pay for any increase in fuel economy is zero and she would actually be willing to pay for a reduction. This conclusion holds regardless of whether one accepts any or all of the proposed technologies on the dotted vertical line as cost-effective in an engineering sense.

**Figure 4: Constrained Consumers Will Not Purchase More Fuel Economy**



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