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Estimating the Benefits of Fuel Economy Information: An Analysis, Update and Recommendations for Enhancing ORNL's Methodology

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Abstract

Since the mid-1970s, the federal government has produced and published information on the fuel economy of new passenger cars and light trucks as required by statute (EPA, 2017a). Beginning in 1999, the Department of Energy (DOE) and Oak Ridge National Laboratory (ORNL) established a website to more efficiently provide fuel economy information to the public. This report reviews the methods and data used by DOE/ORNL to estimate the dollar and petroleum savings due to their fuel economy information efforts. We find that the methods used to estimate savings are reasonable and appropriately transparent, given the existing state of knowledge and available data. Where possible, we updated time-sensitive data. However, empirical data are lacking for many of the key steps in the estimation process which forced DOE/ORNL to make plausible assumptions about important parameters. In general, conservative assumptions have been used, reflecting a preference for under-estimating the program's benefits. In a few cases we recommend even more conservative estimates. We carried out an analysis of the sensitivity of estimated benefits to uncertain parameters. Parameters were grouped into three classes and assigned approximate uncertainty ranges: 1) well supported by empirical data (+/- 10%), 2) supported by incomplete or indirect empirical evidence (+/- 20%) or 3) plausible conjectures (+/-50%). Ten thousand Monte Carlo simulations each were run using first uniform and then triangular probability distributions. Estimated dollar savings in 2016 due to the program's activities in that year alone ranged from a minimum of $40 million to a maximum of $220 million. Estimated savings in all future years due to the program's 2016 activities ranged from $230 million to $1.7 billion. Petroleum savings and estimated greenhouse gas (GHG) reductions were of similar magnitude. We consider the finding that the impacts of the program are orders of magnitude larger than the program's cost to be reasonably robust. Sensitivity analysis indicated that assumptions about the fraction of new car buyers visiting the website www.fueleconomy.gov who changed their new car choices as a result of their visit had the greatest impact on estimated benefits. Next in importance was the increase in fuel economy resulting from information obtained from the website. We make specific recommendations concerning periodic updating of data and the use of online surveys of website customers to develop empirical support of key parameters.

Estimating the Benefits of Fuel Economy Information:
An Analysis, Update and Recommendations for Enhancing ORNL's Methodology[1]

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I. Introduction

Since the mid-1970s, the federal government has produced and published information on the fuel economy of new passenger cars and light trucks (EPA, 2017a). The early program, as formulated in the Energy Policy and Conservation Act of 1975 (Pub.L. 94-163, 89 Stat. 871), required manufacturers to display each new vehicle's fuel economy estimates on a standard window sticker. Dealers were required to stock and prominently display copies of a comprehensive annual *Fuel Economy Guide* listing all vehicles' miles per gallon (MPG) estimates, and to make copies available to the public on request. Responsibility for producing the fuel economy estimates was assigned to the Environmental Protection Agency (EPA). Responsibility for printing and distributing the *Fuel Economy Guide* to dealers was assigned to the Department of Energy (DOE).

At the turn of the millennium, DOE realized that the internet offered a potentially more efficient and effective means of making fuel economy information available to the public. In 1999, DOE and Oak Ridge National Laboratory (ORNL) launched www.fueleconomy.gov, a website offering easy access to fuel economy information on new and used vehicles dating back to model year 1984. The new website took advantage of the internet's ability to facilitate comparisons among vehicles, manage and perform calculations on large data sets, and personalize information for each customer. A wide range of fuel economy information is available on the site, ranging from driving and maintenance tips to descriptions of advanced vehicles and fuels. In its first year of operation, the website hosted 360,000 user sessions and provided information to over 200,000 unique visitors. By 2005, website traffic had grown to nearly 9 million user sessions and over 5 million unique visitors. High gas prices in 2013 attracted over 25 million unique users to access fuel economy information in over 58 million user sessions. Today, fueleconomy.gov remains DOE's most heavily-used website, and is one of the federal government's most popular websites. The number of visitors to the website far exceeds the quarter of a million printed *Fuel Economy Guides* distributed each year.

The website and *Fuel Economy Guide* are not the only channels by which the DOE/ORNL Fuel Economy Information Program makes fuel economy information available to the public. It also actively promotes coverage of fuel economy information by the internet, television, radio, and print and social media.

The objective of the Fuel Economy Information Program is to reduce petroleum

[1] The authors gratefully acknowledge the support of this research by Oak Ridge National Laboratory. The views expressed herein are those of the authors and do not necessarily reflect the views of Oak Ridge National Laboratory, the U.S. Department of Energy or the University of Tennessee

consumption and greenhouse gas emissions by helping consumers make well-informed choices about purchases of new and used vehicles and how to operate and maintain them. Fundamentally, this involves providing information that changes behavior. Theories of behavioral change recognize the importance of information as it affects individuals' judgments about the likely consequences of their actions, as well as their ability to successfully carry out those actions (World Bank, 2017). Presented well, fuel economy information can change individuals' expectations about the effects of their vehicle choices on future fuel costs and their knowledge of how to operate and maintain vehicles to increase on-road fuel economy.

Very large quantities of fuel and greenhouse gas emissions are at stake. Fuel economy improvements to new passenger cars and light trucks since 1975 have saved an estimated 1.5 trillion gallons of gasoline and 30 million metric tons of greenhouse gases (Greene, 2017). This massive impact is illustrated in Figure 1, which shows how fuel use became disconnected from vehicle travel shortly after the implementation of fuel economy standards in 1975. Given the enormous quantity of fuel purchased by U.S. motorists each year, even relatively small changes in vehicle choices and operations can amount to millions of gallons (and dollars) in savings.

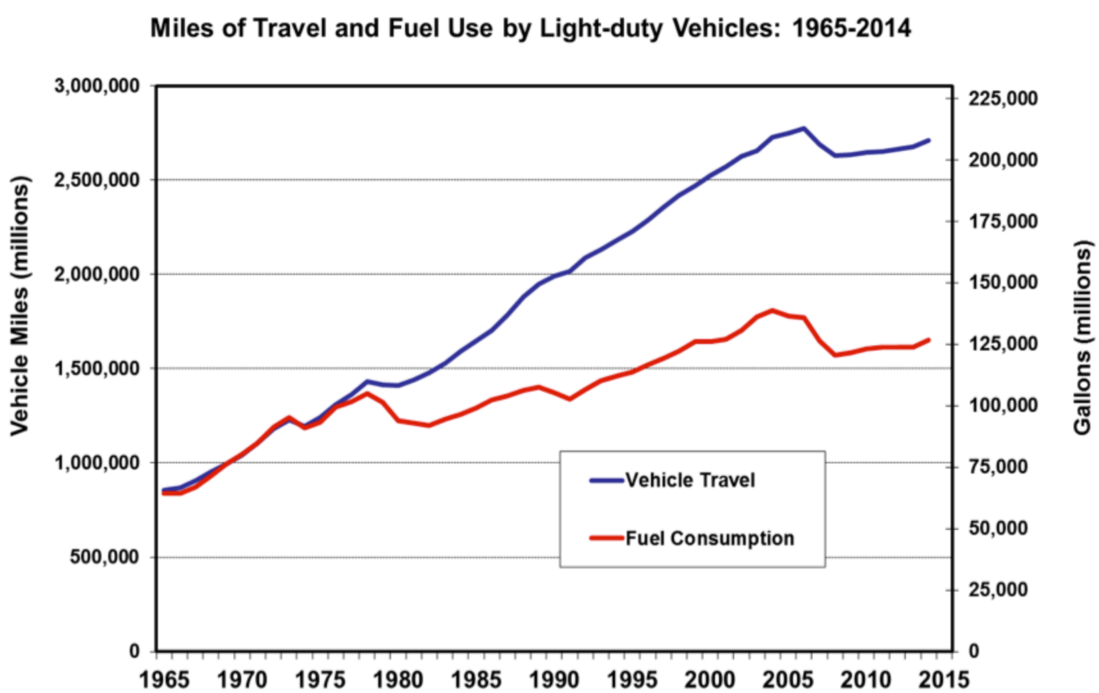

Figure 1. U.S. Miles of Travel and Fuel Use by Light-duty Vehicles: 1965-2014. (Source: FHWA, Highway Statistics, table VM-1, numerous years).

Estimating the impacts of information on behavioral outcomes when it is not possible to conduct a controlled experiment is inherently uncertain. Therefore, the Fuel Economy Information Program employs a straightforward, transparent methodology that combines empirical data with a limited number of parameters, some of which are supported by research and others of which are educated guesses. In this report we review the methods used by DOE and ORNL to estimate the impacts of the Fuel Economy Information Program on oil consumption and savings on motor fuel. To these two metrics we have added the estimation of well-to-wheel impacts on greenhouse gas emissions. We then update data inputs to the model and propose changes in many parameters based either on evidence from more recent research or substituting our own judgments for those previously used. Next, we estimate program impacts for 2016 and conduct a sensitivity analysis to illustrate the uncertainty of the estimated impacts and to identify the parameters with the greatest influence on the estimated program benefits. Finally, we suggest actions that might reduce the uncertainty in key parameter values and produce more robust and accurate benefit estimates.

II. The Benefits Estimation Methodology

Overview of Methodology

Figure 2 illustrates the DOE/ORNL process for estimating the impact of the Fuel Economy Information Program on fuel and oil consumption. The first major input into estimating impacts is data on the number of people exposed to the information presented by the Fuel Economy Information Program. This includes website users, *Fuel Economy Guide* distributions, and readers of print or online articles that mention the Fuel Economy Program and/or even link to fueleconomy.gov. These total users are then broken down into three types: new car buyers, used car buyers, and vehicle owners seeking driving techniques to increase the fuel economy of their vehicle. Calculations are made to avoid double counting website users who both read an article that mentions the Fuel Economy Program and visited the website. Then, the percent of total unique users[2] that are actually affected or change their behavior based on the information is estimated for each type of media (e.g., website, *Fuel Economy Guide*, online or print articles discussing the Fuel Economy Program, etc.) and type of user (e.g., new car buyer, used car buyer, and vehicle operations). In other words, the number of people that are exposed to the Fuel Economy Information Program and alter their vehicle choice or driving behavior such that a higher fuel economy is achieved is estimated for each type of media outlet and user. For all types of users, gallons of gasoline saved are estimated by multiplying the number of users that change their behavior based on the information presented by average vehicle miles traveled (VMT) per year by the gallons per mile of predicted fuel economy improvements. Lastly, the value of fuel savings are approximated.

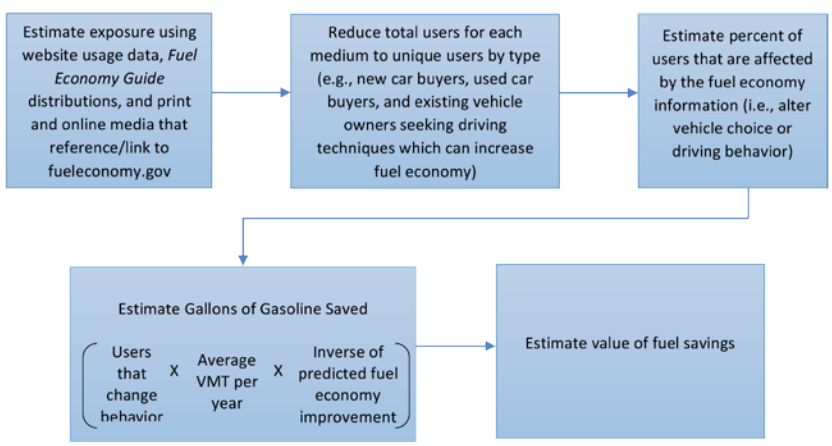

Figure 2. Description of Estimation Methodology

[2] The number of unique users is determined by counting multiple visits by the same device only once.

There are various data inputs and parameters required by the estimation model presented in Figure 2. Here we discuss these and the methodology in further detail. Also, there is dynamic documentation that accompanies the estimation model which describes the methodology, calculations, and data sources. Consistent with the data and parameter updates that we propose below, we revised the corresponding documentation and provided a more detailed description of the usage data. In general, we assign data and parameters used to calculate impacts into three categories of uncertainty. We consider parameters and data to be relatively certain if the values are well-supported and based on sound empirical data. Somewhat uncertain values are based on indirect or analogous empirical evidence. Lastly, uncertain values are educated guesses or formulated through professional judgements. In discussing the current data inputs, we discuss data sources and the level of uncertainty. We also provide a sensitivity analysis of these data inputs and identify which inputs have the greatest influence on estimated impacts.

Usage Data

People are exposed to information from the Fuel Economy Information Program through multiple channels which are considered under the current estimation process. For example, some people directly access information through the website, some download or obtain a copy of the *Fuel Economy Guide* through various distributions, and some are exposed through other media outlets such as online or print news articles, *MotorWeek*[3], or other television broadcasts. Data on website traffic and *Fuel Economy Guide* distributions are the most accessible, and together accounted for about 62% of total media users in the 2015 fiscal year. Because a single user may visit the website multiple times, the current methodology multiplies total website visitors for the current year by the percent of total users who were unique in the previous year to identify current *unique* website users. Users of the *Fuel Economy Guide* are estimated from direct downloads of the guide from the website and from known distributions by libraries, credit unions, new car dealers, National Renewable Energy Laboratory (NREL), and the DOE Office of Energy Efficiency and Renewable Energy (EERE). Numbers of other media users are less known and therefore estimated. For example, online media users (i.e., those that read online articles that discuss or link to fueleconomy.gov) are estimated by multiplying the count of different types of articles that mention the Fuel Economy Information Program such as national television sites, national news sites, local news sites, etc. by the estimated number of readers of such articles.

Estimating the Number of Unique Users that Change Their Behavior

Total users are broken down into three types of users: new car buyers, used car buyers, and existing vehicle owners looking for driving tips and techniques to maximize the fuel efficiency of their vehicle. Currently, it is assumed that 43% of total users are new car buyers, 50% are used car buyers, 3% are looking for vehicle operations to increase fuel economy, and remaining users do not have interest in fuel economy information. For website users, we consider this information to be relatively certain as the values are based on website traffic (e.g., 43% of website visitors look for information about new cars), but we consider this information to be somewhat uncertain for the other media groups. For users of online media, print media, and

[3] *MotorWeek* is a television program devoted to automotive issues produced by Maryland Public Television and carried by 92% of PBS stations nationwide: http://www.motorweek.org/. The Fuel Economy Information Program has supported the creation of many information segments dealing with fuel economy and related issues.

viewers of television broadcasts including *MotorWeek,* additional assumptions are made on the portion of people who access an article (or view a television show) that actually read the article (or watch the television show) and the portion of people who *both* read an article (or watch a television show) *and* access the website. For example, for online media users, it is assumed that 75% of users read the article and 25% read the article *and* access the website. In turn, website users are accordingly adjusted downward to ensure that those that read an article (or view a television show) *and* access the website are not double counted as a website user. Lastly, only a portion of unique users are assumed to change their behavior based on the information. For example, 50% of website users are assumed to alter their behavior by purchasing a more fuel efficient vehicle. For those looking for driving techniques, 50% are assumed to alter their driving behavior such that a higher fuel economy is achieved. As the percentage of users that read *and* access the website and the percentage of users that change their behavior are based on professional judgements, we consider both of these parameters to be uncertain and treat them so in the sensitivity analysis. While percentages vary depending on the type of media user, the following formula summarizes how unique users that change their behavior based on the fuel economy information is calculated.

$$\begin{array}{c}\textbf{Total users}\\ \textbf{by media}\\ \textbf{type}\end{array} \;\mathbf{x}\; \left(\begin{array}{c}\textbf{Percentages by type of user}\\ \text{new car purchasers,}\\ \text{used car purchasers,}\\ \text{or vehicle owners increasing fuel}\\ \text{economy through driving tips}\end{array}\right) \;\mathbf{x}\; \begin{array}{c}\textbf{Percentage of}\\ \textbf{users that change}\\ \textbf{behavior}\end{array} \;=\; \begin{array}{c}\textbf{Unique users that change}\\ \textbf{behavior by media type}\\ \textbf{and type of user}\end{array}$$

Estimating Fuel Savings

Assuming one vehicle per user, annual gallons of gasoline saved are estimated by the product of number of users changing their behavior, average miles driven per year, and the inverse of predicted fuel economy improvements (see formula below). Annual miles traveled are from the DOE *Transportation Energy Data Book* (24th Edition) and are 14,500 and 11,800 miles for new and used vehicles, respectively. Average fuel economy for new and used vehicles is 20.8 and 20.2 MPG, respectively. These data are from the Environmental Protection Agency's (EPA) *Light-Duty Automotive and Technology and Fuel Economy Trends: 1975 Through 2004* report and the U.S. Department of Transportation's *Highway Statistics.* Given that both VMT and average fuel economy values are from well-supported empirical data, we consider these data to be relatively certain. However, average fuel economy improvement is less certain. Currently, new vehicle purchasers who view fuel economy information are assumed to purchase a vehicle with a 3.3% higher fuel economy than they would have otherwise. Used vehicle purchases who view fuel economy information are assumed to reap a 1% increase in fuel economy. Lastly, existing vehicle owners who alter their driving behavior are assumed to reap a 2% increase in fuel economy. We consider the average fuel economy improvements for those purchasing vehicles to be uncertain parameters in the sensitivity analysis. Although, as we discuss in more detail below, fuel economy improvements from driver behavior is somewhat certain as the updated parameter that we propose does rely on previous literature findings.

Unique users that change behavior by media type and type of user	x	Average VMT per year	x	Inverse of predicted fuel economy improvement	=	Annual gallons of gasoline saved

The value of annual fuel savings is found by multiplying gallons saved by fuel cost, which is currently assumed to be $1.50 per gallon. Assuming 42 gallons per barrel of oil, oil savings are calculated as well. Lastly, in addition to annual savings, expected future fuel savings are also estimated. If a consumer purchases a more fuel efficient vehicle due to information presented on fueleconomy.gov or by the Fuel Economy Information Program, the consumer will experience a decrease in fuel consumption not only in the first year but over the entire lifetime of the vehicle. It is assumed that new and used vehicles have expected remaining lifetimes of 15 and 5 years, respectively, and it is assumed that users that alter their driving behavior do so such that fuel economy improvements last for 0.5 years. Then, expected future fuel savings are calculated assuming a 6% discount rate and an annual decline in VMT of 4%. In the sensitivity analysis, we consider these rates to be somewhat uncertain and examine their influence on estimated impacts.

III. Updating Empirical Data

We recommend updating some of the data inputs for the estimation model in order to reflect the most current empirical data. These updates include VMT (for both new and used vehicles), average fuel economy (for both new and used vehicles), and the price of fuel. Lastly, we added an additional metric, the well-to-wheel greenhouse gas (GHG) emissions saved as a result of decreased fuel consumption, to provide an additional way to estimate the impact of the Fuel Economy Information Program.

For VMT per year, we updated VMT to 14,368 (from 14,500) for new vehicles and to 11,271 (from 11,800) for used or in-use vehicles. Previous estimates were based on the U.S. Department of Transportation's 2001 National Household Travel Survey (NHTS). While the updated estimates are similar to previous estimates used, the updated vehicle mileage is the reported best estimate from the 2009 NHTS.

Previously, average fuel economy was assumed to be 20.8 and 20.2 MPG for new and used vehicles, respectively. These fuel economy estimates are from the EPA's *Light-Duty Automotive and Technology and Fuel Economy Trends: 1975 Through 2004* report and the U.S. Department of Transportation's *Highway Statistics.* Based on EPA's 2016 report and *2014 Highway Statistics*, the most recently available data, we updated these values to 24.8 and 21.4 MPG for new and used vehicles, respectively.

To calculate the value of fuel savings, annual gallons of gasoline saved are multiplied by the price of fuel. We updated the price of fuel from $1.50 to $1.745. The updated gasoline price is the average of the U.S. Energy Information Administration (EIA) monthly gasoline prices (all grades, U.S. city average) over the 2016 fiscal year (October 2015 through September 2016), which aligns with the same time period that web usage data are collected. Also, we subtracted the federal gas tax rate ($0.184) and the average of state gas taxes and fees ($0.266), which are from the U.S. Department of Transportation's *Highway Statistics* and reported by EIA as of July 2016.

Lastly, we incorporated an estimate of annual and lifetime reductions in CO_2 emissions that are associated with fuel savings. The well-to-wheel conversion factor of 11.012×10^{-3} metric tons of CO_2 per gallon of gasoline consumed is from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) 1 2016 model (GREET WTW Calculator), which was developed by Argonne National Laboratory and sponsored by DOE-EERE. This conversion factor allows us to calculate the emission reductions in CO_2 that are associated with fuel savings from the Fuel Economy Information Program.

IV. Recommended Revisions to Parameters

Our recommended changes to key parameters can be divided into two categories: 1) parameter values we believe are better supported by recent research and, 2) those for which our judgment about highly uncertain parameters differs from the previous values.

Recent empirical evidence suggests increasing the estimated impact of driving and maintenance tips from 2% to 2.7% based on a recent study by researchers at the University of California at Davis (Kurani et al., 2015). This study found that drivers who were exposed to devices providing real-time feedback on the fuel efficiency of their driving style reduced their real-world fuel consumption by 2.7%. The subsample of drivers who stated they were motivated to save gas did far better, averaging a 9.3% reduction in fuel consumption. In addition to being a recent study, the advantages of this study are a rigorous sampling and experimental design and precise measurements of changes in fuel economy. Its chief disadvantage is that is does not measure the effects of reading information online or viewing a video, but rather of the impact of devices that provide real-time feedback. In this respect, it may over or underestimate the impacts of information provided by other means. It does, however, measure the impact of information about more efficient driving behaviors on a realistic sample of drivers with varying degrees of motivation under actual driving conditions. It seems reasonable to assume that those accessing driving and maintenance tips on www.fueleconomy.gov are more motivated than the average motorist and therefore might achieve better results. On the other hand, in-vehicle driver feedback devices may be more (or less) effective than web-based information. In any case, the increase to 2.7% is a minor modification of the value previously used (2%). A principal motivation for choosing it is to connect the estimate used to a rigorous study with a well-defined interpretation.

We also recommend reducing the impact of fuel economy information on the fuel economy of used vehicles from 1% to 0.5%. The effect of fuel economy information on used car MPG works in a fundamentally different way from the effect on new car MPG. If fuel economy information causes a typical website user to purchase a new vehicle with 3.3% higher fuel economy (the current assumption), then it is reasonable to assume that a vehicle with 3.3% better fuel economy is added to the fleet and will get very close to that much better fuel economy over its lifetime. But the fleet of used vehicles is almost fixed. If website users choose used vehicles with better fuel economy, others will purchase the alternative used vehicles with lower fuel economy, albeit at a slightly lower price due to reduced demand. This lower price will result in earlier scrappage for the lower fuel economy vehicles. While there is a literature on accelerated scrappage policies (e.g., Sandler, 2012), none of the studies corresponds well to an information-based shift in demand. A study of the impact of gasoline prices on the prices and market shares of vehicles with differing fuel economies can be used to illustrate that the impact of a given price change on used car MPG must be far smaller than the impact on new car MPG. Using gasoline price elasticities from Busse et al. (2013), we calculate that a 3.3% change in new car fuel economy corresponds roughly to an increase in the price of gasoline from $2.00 to $2.40 per gallon. Using gasoline price elasticities from the same paper for used car market shares, the same $2.00 to $2.40 per gallon price increase raises the MPG of used car transactions by only 0.1%.[4] As the authors note, the used car results tend to be statistically insignificant and differ in interpretation. Thus, we do not recommend using 0.1% for the impact on used cars, but we do recommend using a smaller number than 1%, and we suggest 0.5% until better information becomes available.

We also recommend downward revisions in several parameters that relate total users of a given media to the numbers who actually read an article or viewed a program, and the percentages of those individuals who changed their behavior as a consequence. These changes are based solely on our different opinions about the likelihood of the event in question. We reduced the percentage of readers of a print or online media who would read a given article referencing fueleconomy.gov from 75% to 20%. We are aware of no data to support either assumption. Our view is that in such cases it is preferable to err of the side of underestimating program benefits when, as will be seen below, the resulting program benefit estimates are orders of magnitude greater than program costs. We reduced the number of typical viewers of the PBS program *MotorWeek* who could be expected to view a given segment on fuel economy from 90% to 50%. Finally, we reduced the percentage of viewers or readers of media content referencing fueleconomy.gov who will change their behavior from 25% to 10%. We cannot prove that these changes are more correct nor can we disprove the previous assumptions. In the concluding section of this report we suggest ways to collect empirical data to inform such assumptions.

We also reduced the probability that an individual who reads an online article that references fueleconomy.gov will access the fueleconomy.gov website. This judgment is based on indirect empirical evidence. In general, "click through" rates for internet ads are single digit percentages. On the other hand, it is reasonable to assume that readers of articles referencing fueleconomy.gov have a greater interest in fuel economy and might be more likely to follow a link to the website. Based on this information and reasoning, we lowered the estimate of the percent who would access fueleconomy.gov as a result of reading on online article from 25% to 5%.

V. Sensitivity Analysis

The scarcity of empirical data and rigorous studies to support the parameters necessary to estimate the benefits of the Fuel Economy Information Program makes such estimates uncertain. Sensitivity analysis is useful for illustrating that uncertainty. It can also help identify those parameters with the greatest influence on the benefit estimates, which can guide future efforts to

[4] As Busse et al. (2013) point out, the new and used car elasticities are not directly comparable. The new car elasticities represent changes in unit sales while the used car elasticities represent changes in market transactions, which is not the same as changes in the composition of the used vehicle fleet. We use their results here only to demonstrate the much lower sensitivity of the used car market to the price of gasoline.

produce more accurate estimates.

Using the updated and modified benefits estimation spreadsheet, we carried out a sensitivity analysis using the @Risk™ software (Palisade, 2013). First, we categorized 86 parameters as either, 1) based on sound empirical data, 2) based on indirect or analogous empirical evidence, 3) based on judgment without the benefit of relevant empirical evidence. For parameters assigned to categories 1, 2, and 3 we assumed uncertainty ranges of +/-10%, +/-20% and +/-50%, respectively. Two simulations were run, first using uniform probability distributions and then triangular probability distributions. In both simulations all the random variables were assumed to be independent. Ten thousand iterations were run for each simulation.

We do not claim that the sensitivity analysis correctly describes the uncertainty in benefits estimates. Clearly, if we know little about a parameter's central tendency we know even less about its probability distribution and about correlations among those distributions. For this reason, we used the simplest available distributions and chose round uncertainty ranges that fell between 0% and 100% and were logically ordered from least to most uncertain. The simulations can only illustrate the range of uncertainty about benefits that results from the assumed uncertainties in the key parameters. Likewise, our analysis of the sensitivity of estimated benefits to different parameters is conditional on the distributions assumed.

Uniform Distributions

The first simulation uses uniform distributions which describe maximum uncertainty over a specified interval. Estimates of the following outcomes of the Program's 2016 activities were calculated:

1. Dollar savings from reduced fuel consumption that occurred in 2016 only,
2. Dollar savings from reduced fuel consumption for as long as the changes induced in 2016 are expected to persist, (e.g., over the expected lifetime of a new vehicle),
3. Reduced oil consumption in 2016 only,
4. Reduced oil consumption for as long as changes induced in 2016 persist,
5. Reduced GHG emissions in 2016 only,
6. Reduced GHG emissions for as long as the changes induced in 2016 persist.

In the text, all estimates are rounded to two significant digits to better reflect the fact that they are rough approximations. Dollar savings exclude motor fuel taxes since they are transfer payments.

Dollar savings realized in 2016 as a consequence of the actions taken in 2016 range from a minimum estimate of $40 million to a maximum of $220 million, with a mean estimate of $100 million (Figure 3). Ninety percent of the simulations fall between $60 million and $160 million.

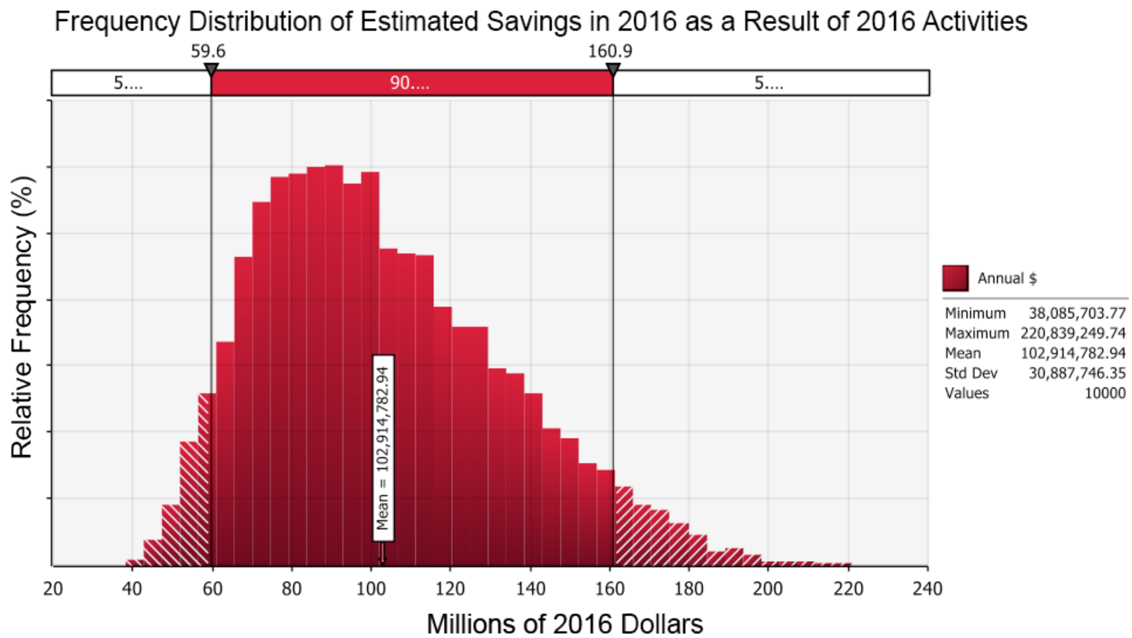

Figure 3. Frequency Distribution of Estimated Savings in 2016 as a Result of 2016 Activities.

Savings due to 2016 activities accumulated over future years range from $230 million to $1.7 billion, with a mean of $720 million (Figure 4). Ninety percent of the simulations fell between $390 million and $1.2 billion.

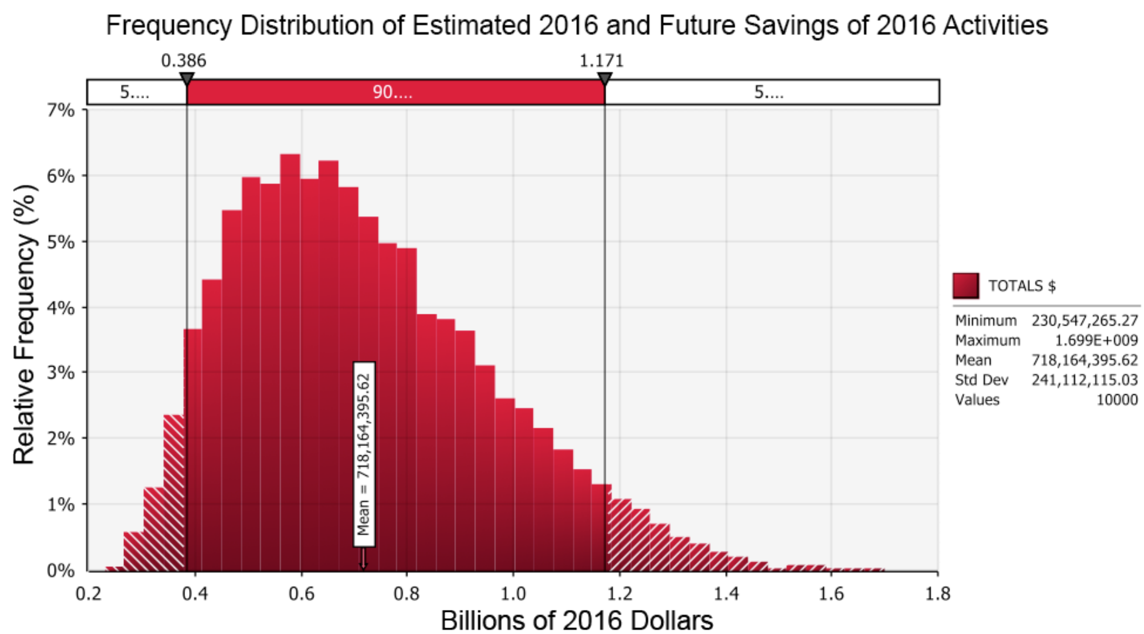

Figure 4. Frequency Distribution of Estimated 2016 and Future Savings of 2016 Activities.

The Program's activities in 2016 are estimated to have reduced U.S. petroleum consumption in 2016 by 520 thousand to 3.0 million barrels, with a mean estimate of 1.4 million barrels (Figure 5). Ninety percent of the simulations fell between 810 thousand and 2.2 million barrels.

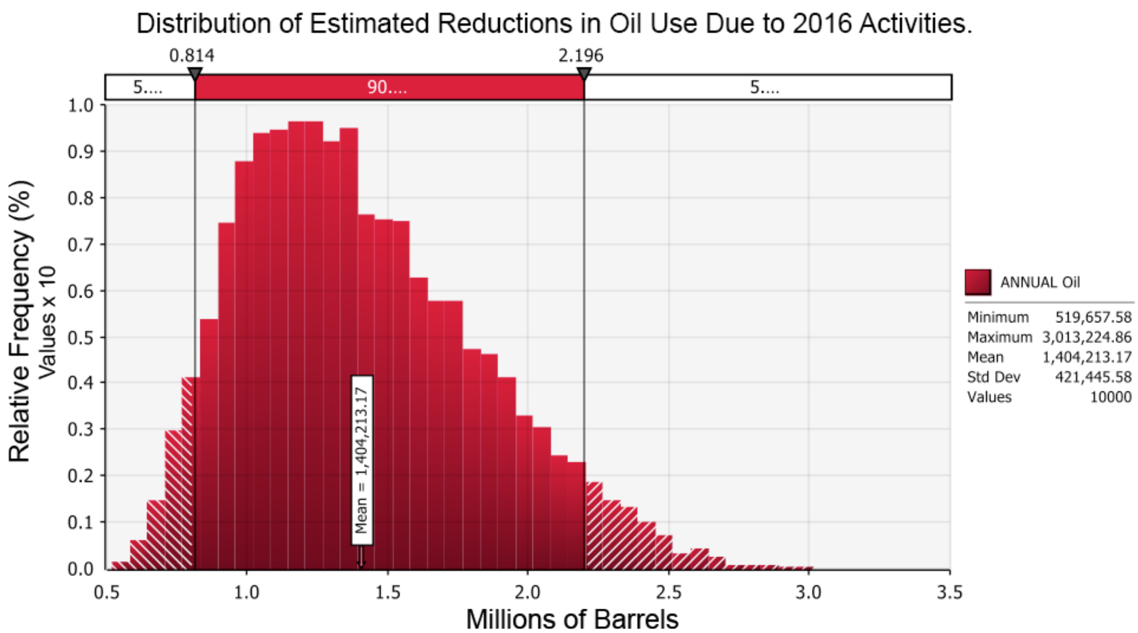

Figure 5. Distribution of Estimated Reductions in Oil Use Due to 2016 Activities.

Including the future impacts of activities in 2016 results in a range of oil savings of 4.3 million to 33.6 million barrels with a mean of 14 million barrels (Figure 6). Ninety percent of the simulations produced estimates in the interval from 7.4 million to 23 million barrels.

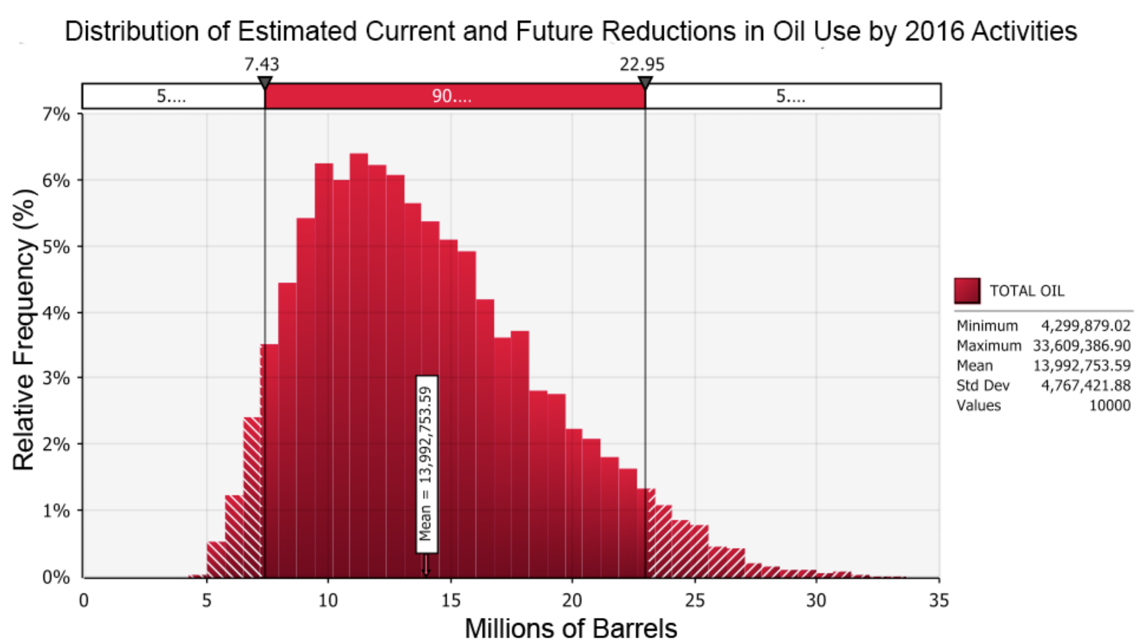

Figure 6. Distribution of Estimated Current and Future Reductions in Oil Use by 2016 Activities.

The estimated GHG emissions reductions realized in 2016 range from 240 thousand to 1.4 million metric tons with a mean estimate of 650 thousand tons (Figure 7). The middle 90% of the estimates fell in the interval from 380 thousand to 1.0 million tons. Assuming a social cost of carbon of $36 per metric ton, the value of these reductions would range from $9 million to $50 million with a mean value of $23 million (IWGSCC, 2015)[5].

Including impacts of 2016 activities in future years increases the range of emissions reductions to 2.0 million to 15 million tons, with a mean estimate of 6.5 million (Figure 8). Ninety percent of the simulations produced estimates between 3.4 million and 11 million tons. The value of emissions reductions at $36 per metric ton would range from $72 million to $0.5 billion.

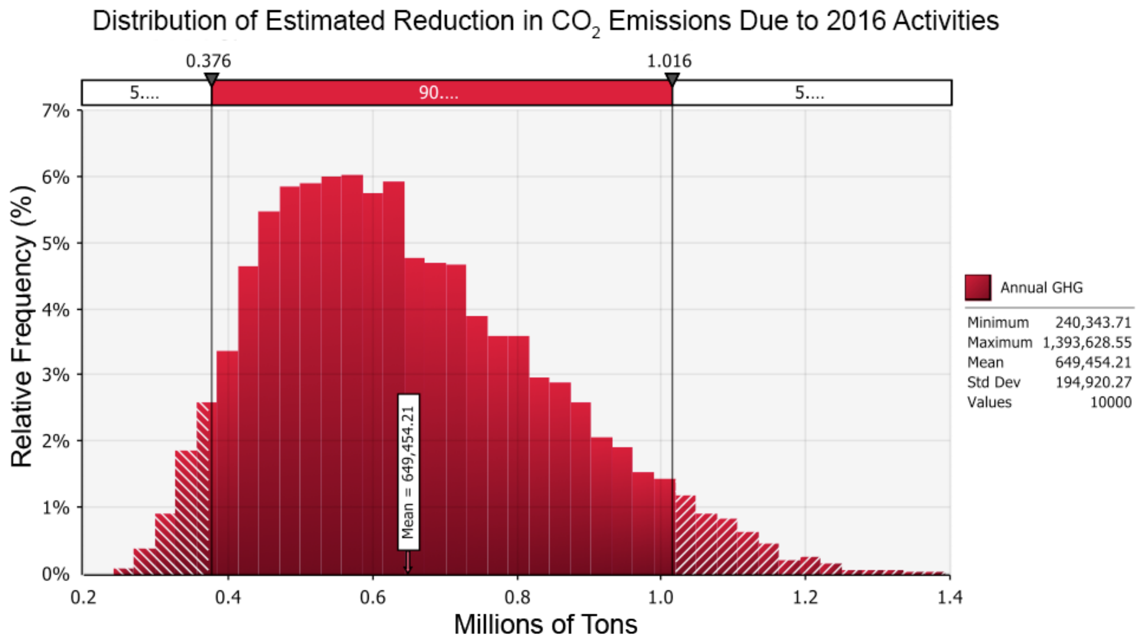

Figure 7. Distribution of Estimated Reduction in CO_2 Emissions Due to 2016 Activities.

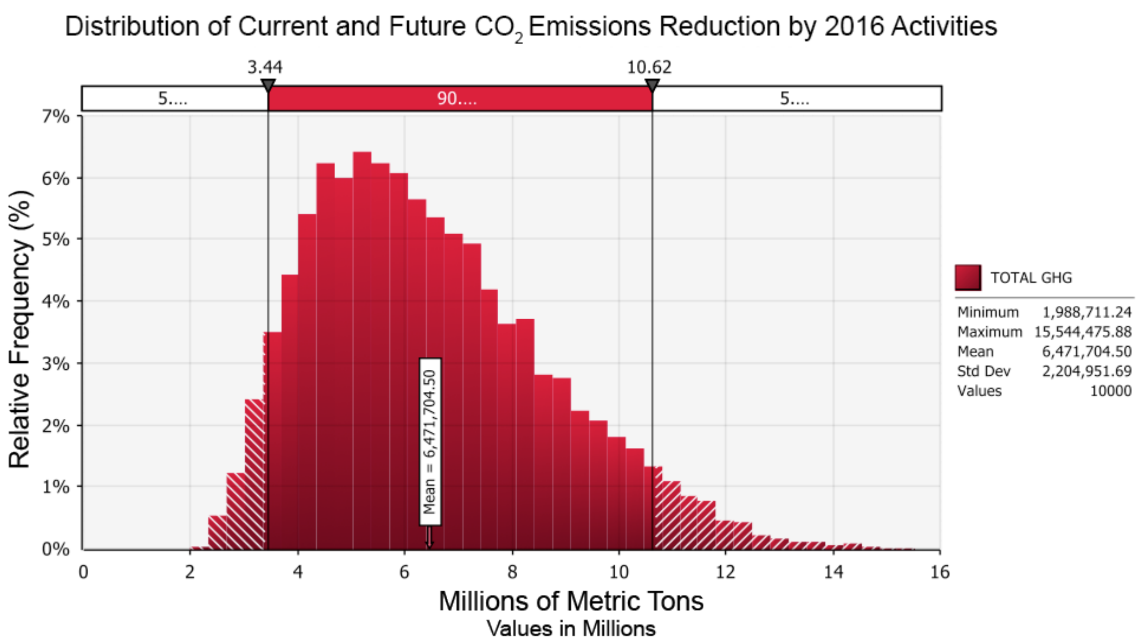

Figure 8. Distribution of Current and Future CO_2 Emissions Reduction by 2016 Activities.

[5] The value of $36 per metric ton represents the Working Group's estimate for emissions in 2015 using a 3% annual discount rate. At discount rates of 5% and 2.5% the values would be $11 and $56 per ton, respectively.

In the following simulations, we substituted triangular distributions for uniform distributions. Triangular distributions are based on the same ranges of uncertainty and the same mean values for parameters as the uniform distributions. However, because of their shape they assign less probability to the more extreme values. As a consequence, these simulations produce narrower ranges of outcomes and narrower 90% intervals.

Estimated dollar savings in 2016 range from $50 million to $190 million with a mean of $100 million (Figure 9). Ninety percent of the simulations fell between $70 and $140 million.

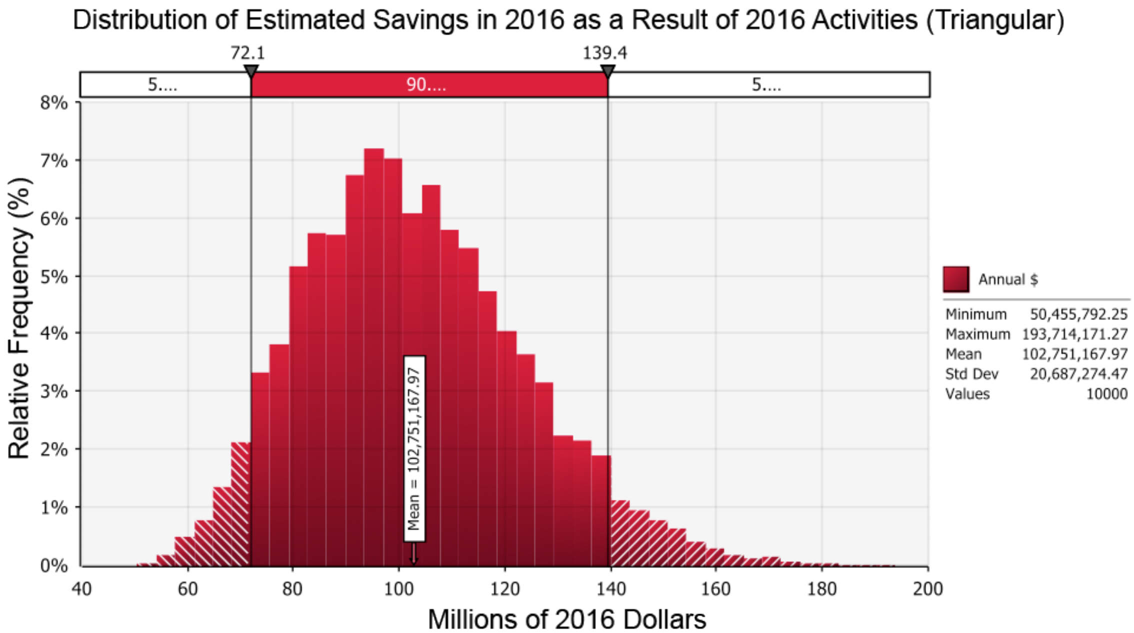

Figure 9. Distribution of Estimated Savings in 2016 as a Result of 2016 Activities (Triangular).

Considering the future impacts of 2016 activities increases the range of estimated savings to $320 million to $1.4 billion with a mean of $720 million (Figure 10). The middle 90% of the estimates range from $480 million to $1.0 billion.

The influence of the uncertain parameters on benefits estimates can be measured by regressing the benefits measures on the parameter values from different simulations. Tornado charts illustrate the influence of each parameter ranked from the strongest to the weakest impact. The magnitude of a parameter's regression coefficient measures the change in the respective benefit measure for a unit change in the parameter. Because the benefits metrics are highly correlated (all are a function of the reduction in fuel consumption) we show tornado charts only for dollar savings. We show results for both 2016 alone and total savings and for the uniform and triangular probability functions.

Using triangular uncertainty distributions, the percent of visitors to fueleconomy.gov who act on information found at the website when considering purchases of new cars (fe.gov New Car / % Acting) has the greatest impact on the estimated benefits of the Fuel Economy Information Program (Figure 11). Almost equal in importance is the impact information from the website has on customers' vehicle choices (fe.gov New Car / Impact). The reference assumption is that a customer considering purchasing a new vehicle would, after comparing vehicles on the website, chose a vehicle with 3.3% better fuel economy, or about 0.8 MPG for a typical light-duty vehicle. The fueleconomy.gov website can have some influence over both parameters by facilitating learning from comparisons among vehicles and encouraging efficient vehicle choices.

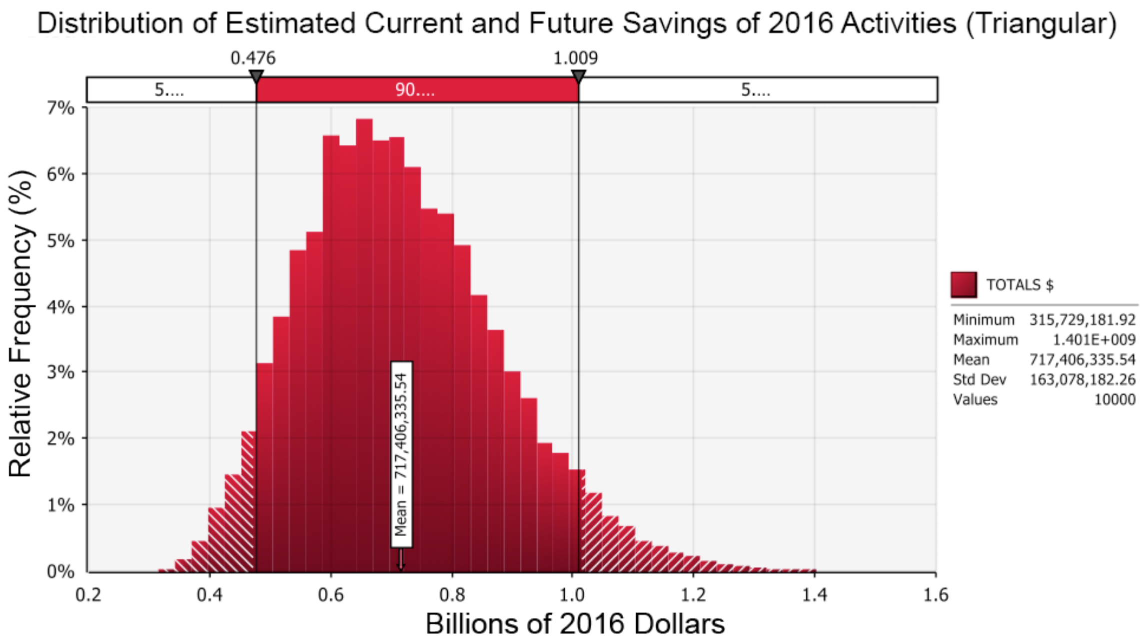

Figure 10. Distribution of Estimated Current and Future Savings of 2016 Activities (Triangular).

The next two most important parameters, VMT/year and New Vehicle MPG, are ones over which the Fuel Economy Information Program has little control. Both parameters are relatively accurately estimated (uncertainty category of +/- 10%) and are based on data from the EPA and the U.S. Department of Transportation's National Household Travel Survey and *Highway Statistics.*

The number of visitors who are considering purchasing a new vehicle is next in importance. This is estimated by the fraction of customers who select pages comparing the fuel economies of new cars. While this should be an accurate estimate of the number of customers interested in new vehicles, it is not clear that all actually intend to purchase a new vehicle within the year. Collecting data from website users via an online survey could produce more accurate estimates for this parameter.

Next in estimated importance are two parameters pertaining to used car buyers: the percent acting on information and the impact of that information. These are followed by the fraction of individuals who view fuel economy driving and maintenance tips and act on that information. Next is the average MPG of all vehicles on the road, a parameter over which the Fuel Economy Information Program has limited influence.

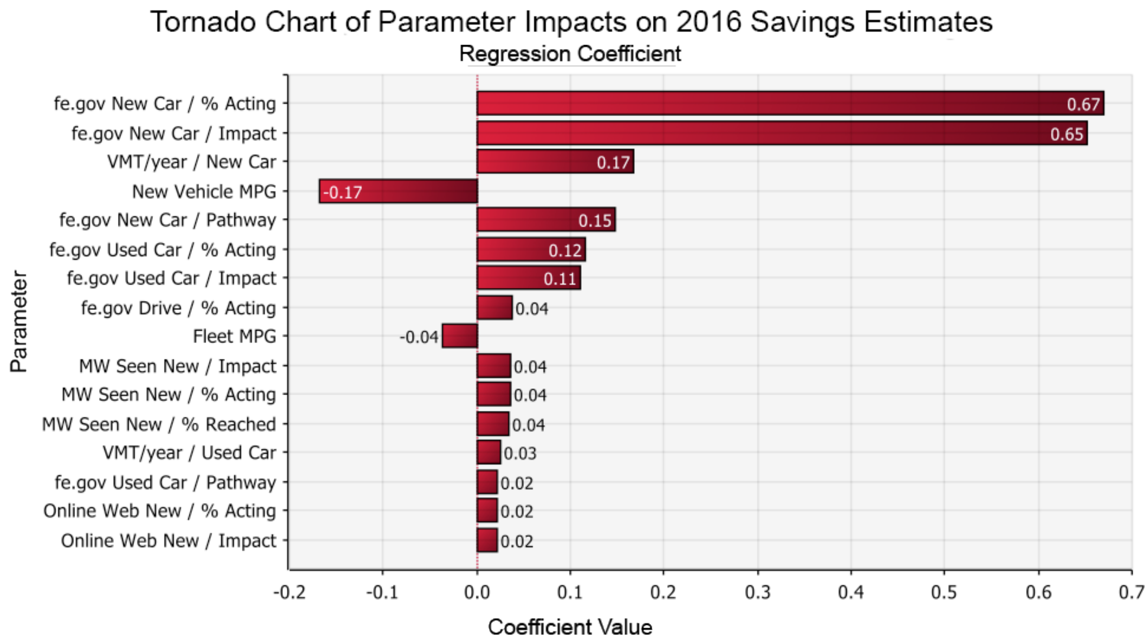

Figure 11. Tornado Chart of Parameter Impacts on 2016 Savings Estimates.

Parameters related to *MotorWeek* (MW) segments appear next: impact, percent acting on information and percent of *MotorWeek* viewers who see the fuel economy segments. Next comes vehicle usage, again a factor over which the Program has almost no influence. The fraction of website customers interested in used cars comes next. Last in this incomplete list are new car buyers who viewed content referring to fueleconomy.gov on other websites. Although the influence of other media on fuel savings is estimated to be small, the impact of publicity from the wider media on the public's awareness of fueleconomy.gov is not measured and could be extremely important to generating website traffic.

The factors affecting both current and future savings due to activities in 2016 are very similar but include additional parameters relevant to future values, such as the discount rate, rate of decrease in vehicle use with age and expected vehicle life (Figure 12). For all practical purposes, such factors describe the state of the world and cannot be influenced by the Fuel Economy Information Program.

Substituting uniform for triangular probability distributions changes the analysis of parameter impacts very little. Factors adjacent in the ranking of impacts frequently exchange places but the magnitudes of impacts are almost identical and the set of parameters having the most important impacts is the same (Figures 13 & 14).

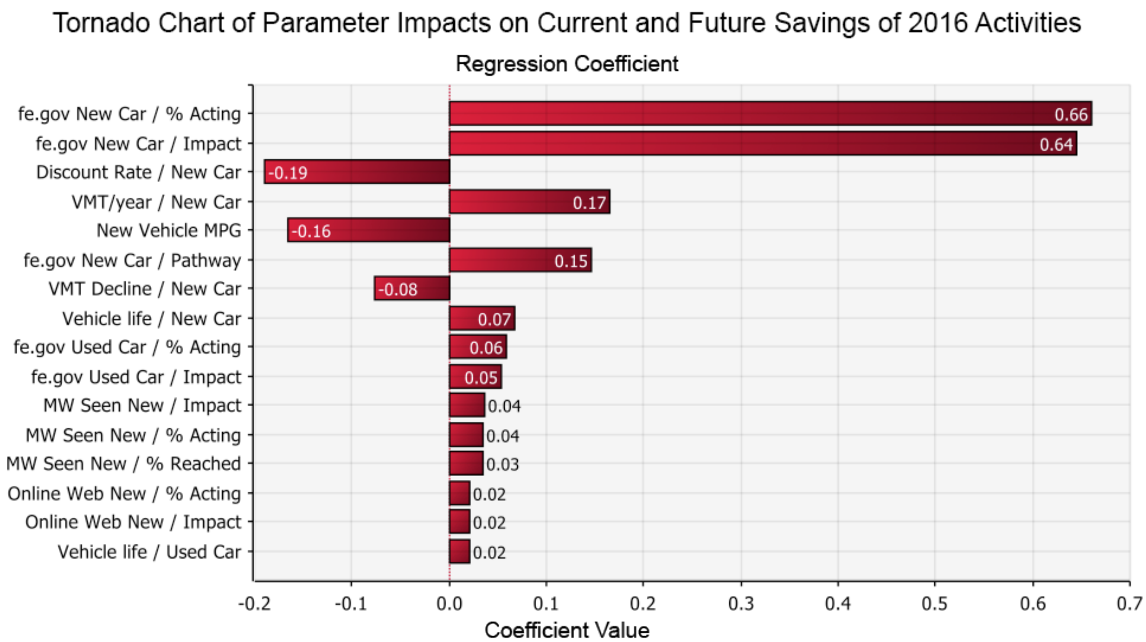

Figure 12. Tornado Chart of Parameter Impacts on Current and Future Savings of 2016 Activities.

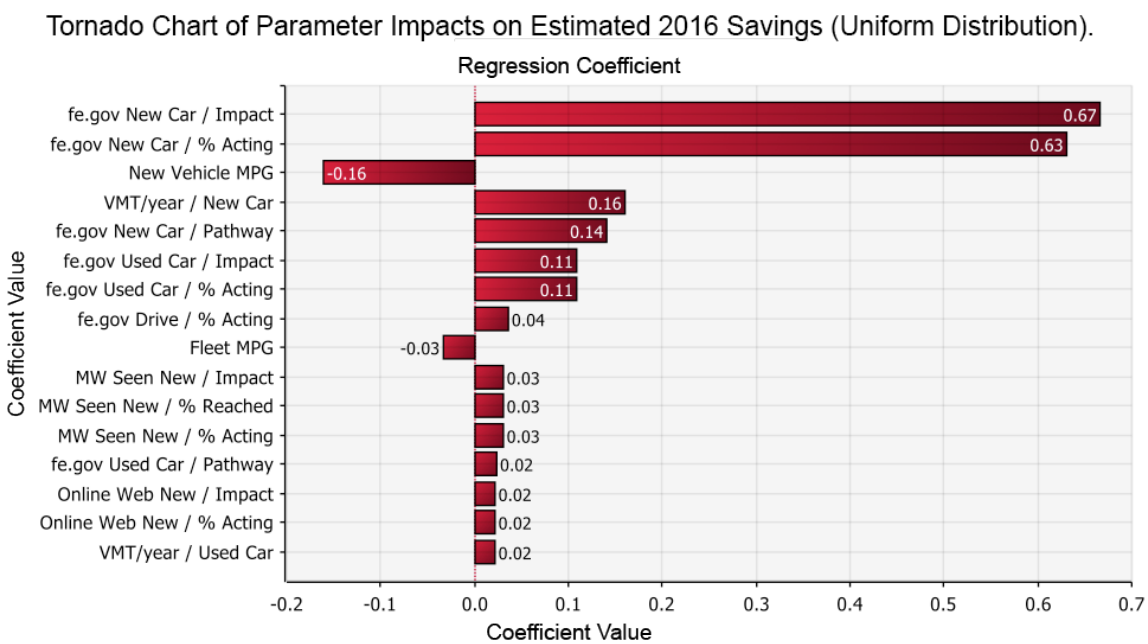

Figure 13. Tornado Chart of Parameter Impacts on Estimated 2016 Savings (Uniform Distributions).

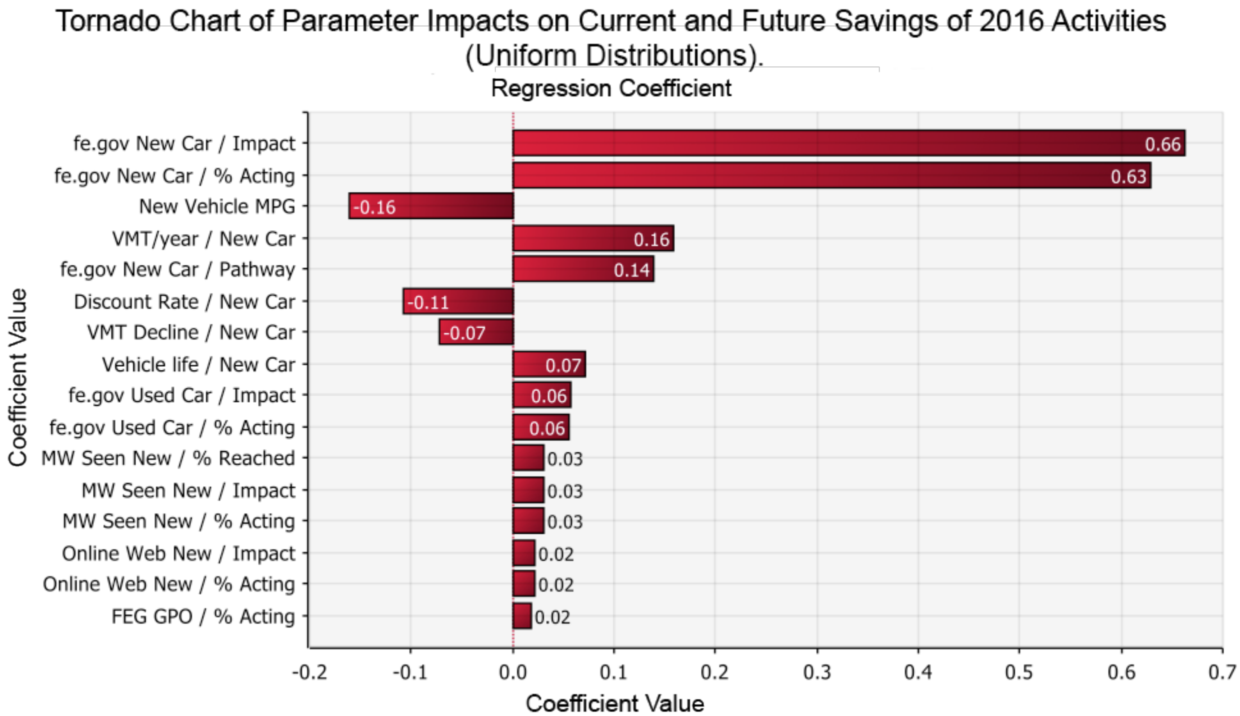

Figure 14. Tornado Chart of Parameter Impacts on Current and Future Savings of 2016 Activities (Uniform Distributions).

The sensitivity analysis identifies the fraction of new car buyers who changed their vehicle choices (fe.gov New Car / % Acting) and the increase in the fuel economy of the vehicle they purchased (fe.gov New Car / Impact) as by far the most important parameters affecting the Program's estimated benefits. Relatively little is known about these parameters, which suggests that they should be the primary focus of research to improve the benefits estimates.

The current methodology implicitly assumes that individuals who viewed information about new vehicles on the website intend to purchase a new vehicle. The next step in the method divides those who viewed the information into those "affected" by it (those who changed their choices) and those not. This one step might be better divided in two: 1) how many viewers of new vehicle information intend to purchase a new vehicle in a given year and, 2) how many of those intending to buy a new car and viewing the information changed their choice as a result. This change in methodology would add rigor and create an opportunity to introduce empirical data. For example, there are approximately 125 million households in the U.S. and 17 million light-duty vehicles purchased each year. If household members visited the website entirely randomly, we might expect about 15% to be in the market for a new vehicle. Of course, one would expect individuals visiting a website dedicated to fuel economy information who view content on new vehicle fuel economy to be more likely than the average household to be in the market for a new vehicle. In the absence of any data, we did not change the existing estimate of 50% affected but rather added uncertainty bounds of 25% to 75%. However, it should be possible to obtain useful if not definitive data on this subject by means of online surveys of fueleconomy.gov customers.

The current methodology was designed at a time when fuel economy and GHG emission standards were not requiring substantial improvements in new vehicle fuel economy, as they are today. Assuming the current standards are a binding constraint on manufacturers, the benefits of the Fuel Economy Information Program may be realized primarily in relaxing that constraint by increasing consumer demand for fuel economy. This should reduce the marginal cost of increasing fuel economy, providing economic benefits to manufacturers and consumers. It might also allow manufacturers to exceed the standards by more than they otherwise would have as a form of insurance against failing to achieve the standards. The current methodology does not address these issues and developing a new methodology that does so is outside the scope of our analysis. However, even very rough calculations indicate the potential for large benefits from such impacts. Estimates of the costs of increasing fuel economy in passenger cars range from approximately $50/MPG for small improvements to $100/MPG and $250/MPG at moderate and high levels (NRC, 2015). Assuming an estimated 2 million potential vehicle purchasers affected by the Fuel Economy Program's information and an impact of 3-4% (about 1 MPG), program benefit estimates are still likely to be on the order of $100 million.

VI. Findings and Recommendations

Findings on the Size of Benefits

1. It is virtually certain that the benefits of the Fuel Economy Information Program exceed its costs many times over. This result holds despite the more conservative assumptions used in this assessment. Even the lowest estimates of direct savings to consumers from our sensitivity analysis are approximately ten times the Program's annual budget, and the direct savings estimates do not include the sizable monetized values of reduced GHG emissions and reduced oil dependence.
2. Affecting new car choices is by far the most important pathway by which benefits are realized. This finding indicates that the program should continue its emphasis on reaching and affecting the choices of new car buyers. On the other hand, almost nothing is known about how fuel economy information affects used car choices and the fuel economy of the existing stock of vehicles. Research in this area could develop new insights that might increase the importance of fuel economy information in used car choices.
3. For both new and used car choices, the percent of customers viewing fueleconomy.gov content who change their behavior (choices) and the magnitude of the impact on the fuel economy of vehicles they choose are the two most important determinants of the Program's benefits.
4. *MotorWeek* segments appear to play a smaller but still important role in producing fuel savings.
5. The direct impacts of citations and links from other online media appear to be small. However, because the benefits estimation methodology does not include the value of publicity for both fueleconomy.gov and public awareness of fuel economy issues in general, the indirect benefits of broader media coverage are almost certainly substantially underestimated.

Findings on the Methodology

1. The method of estimating benefits currently in use is reasonable and transparent and generally appropriate for the nature of the task, the state of knowledge and the available

data.
2. The Program should consider developing additional methods to estimate savings conditional on the existence of fuel economy and GHG standards. These methods would focus on savings due to reductions in marginal costs of fuel economy technologies and possibly the value to manufacturers of exceeding the standards as a form of insurance against failing to meet the standards.
3. If possible, the Program should design and implement online surveys of customers of www.fueleconomy.gov to develop empirical support for key parameters, such as:
    a. Fraction of website users who intend to purchase a new car in the current year.
    b. The frequency, nature and impact of behaviors that result from exposure to fuel economy information.
    c. For new car buyers, the difference in fuel economy between the car actually purchased and the cars they were considering before visiting fueleconomy.gov.

Findings on Data and Parameters

1. We recommend adopting the more detailed descriptions of data sources and methods of collection (especially methods of calculating usage data) that we have added to the previous existing documentation that accompanies the estimation model. For example,
    a. Unique website users is calculated by multiplying total website users by the percent of users that were unique in the previous year. We understand this is due to the limitations of the software currently used to track website traffic. If possible, it would be preferable to adopt software that can distinguish unique users from total website visits.
    b. Estimates of the percentage of total viewers of online media who read an article mentioning fueleconomy.gov are highly uncertain. Currently, the number of people exposed to an article posted on a specific day is found by multiplying unique monthly visitors by average visits per month by (1/30). Then it is assumed that only 0.5 to 1% (depending on the site) will actually see or notice the article. While it is better to err on the side of under-estimating impacts, these percentages may be too low, especially as it is then assumed that only 20% of those that notice an article will actually read the article. Article counts are updated annually but estimates of monthly website visitors are from 2006. We recommend an exploratory effort to determine whether it is possible to obtain updated relevant empirical data.
    c. For online media, the number of various types of articles (e.g., online national newspapers/magazines sites, local news sites, etc.) is multiplied by the estimated number of people who read the articles. It appears that the number of readers has not been updated since 2007. We suggest updating these data if they are available.
    d. Print media users is calculated by multiplying the number of print media users in 2007 (which is ultimately based on the number of users in 2004) by the ratio of article counts in the current year to that in 2007. Users for television affiliates is calculated similarly. If more recent data are available on the number of print media readers, we recommend updating this input. Users for television affiliates is calculated in a similar way and should also be updated given data are available.

e. If possible, we suggest updating the number of *MotorWeek* viewers on an annual basis. It appears that this has not changed since 2013, although this may certainly be accurate.

2. We recommend providing annual updates to data inputs, such as vehicle mileage, average fuel economy estimates, and fuel prices, with the most recently available empirical data (sources cited above).
3. Assuming the data allow, we suggest ensuring that the percentages by pathway (e.g., new car choice, used car choice, vehicle operations, and no interest in MPG) for website traffic are based on the current year's website traffic data. It appears these values have not changed since 2006.
4. Lastly, we recommend incorporating usage data and impacts of mobile apps as they are developed, such as the Find-a-Car mobile app.

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