

ISSUE BRIEF

# Let's Turn CAFE Regulation on Its Head

Carolyn Fischer



RESOURCES  
FOR THE FUTURE



May 2009  
Issue Brief # 09-06

## Resources for the Future

Resources for the Future is an independent, nonpartisan think tank that, through its social science research, enables policymakers and stakeholders to make better, more informed decisions about energy, environmental, natural resource, and public health issues. Headquartered in Washington, DC, its research scope comprises programs in nations around the world.



1616 P Street NW  
Washington, DC 20036  
202-328-5000  
[www.rff.org](http://www.rff.org)



## Let's Turn CAFE Regulation on Its Head

Carolyn Fischer<sup>1</sup>

In thinking about fuel economy, Americans have chosen to focus on mileage: how far can I travel on a given amount of fuel? In Europe and most other countries, however, they ask the inverse question: how much fuel does it take to go a certain distance? Of course, these questions are really two sides of the same coin: the former asks about value, while the latter asks about cost. However, since our regulatory policy is motivated by costs—the costs of fuel to consumers, the environmental costs of burning it, and the energy security costs of depending on it—there are some important practical reasons why focusing on gallons per 100 miles (GPHM) would be a better indicator of fuel economy than our current miles per gallon (MPG) metric.

### Reason 1: Help Consumers

When purchasing a car, consumers want to weigh the costs and benefits of different alternatives. Most consumers know how much driving they want to do: it depends on their commute, their family lifestyle, recreational habits, and so on. It does not depend on which model they choose; rather, the opposite is the case. Therefore, it makes more sense to hold that value constant and think about comparing the costs of achieving that value across different vehicles.

Yet, consumers have a hard time comparing costs using MPG ratings; in fact, they systematically misjudge actual fuel economy improvements (Larrick and Soll 2008). The U.S. Environmental Protection Agency has recognized the difficulty of going from MPG to fuel costs. In its revision to fuel economy labels in 2006, it made the estimated annual fuel costs much more prominent; however, it may still be difficult for a consumer to change the assumptions about gas prices, annual miles traveled, and shares of city and highway driving. For many people, it is much easier to multiply than to divide (Huff et al. 1999), but any personalized calculation of fuel costs from the MPG label would require some division to get there.

.....  
<sup>1</sup> Carolyn Fischer is a senior fellow at Resources for the Future, 1616 P Street, NW, Washington, DC 20036. Email: [fischer@rff.org](mailto:fischer@rff.org). I am grateful to David Bernstein for calling my attention to this issue. All errors and omissions are my own.

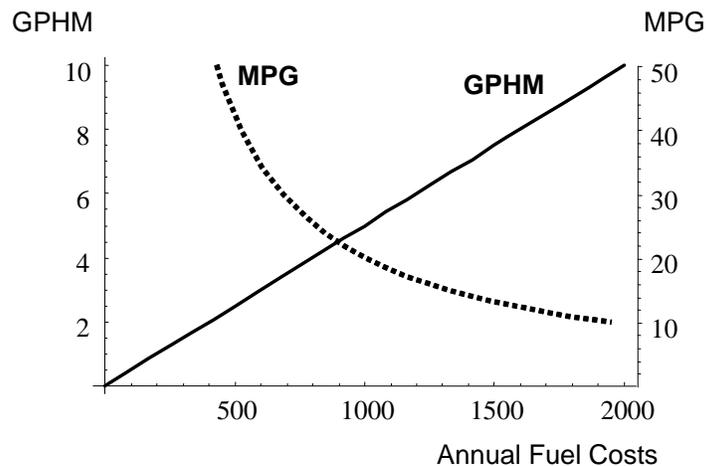


Calculating fuel costs is much simpler using GPHM. You just multiply the rating by however many hundreds of miles you drive—per year, month, or trip—and multiply that by the gasoline price to get your fuel costs for that time frame. No need for division, allowing for much easier back-of-the-envelope calculations.

## Reason 2: Improve Transparency

Another nice feature of GPHM is that fuel costs rise directly in proportion to that rating. Thus, a 10 percent decrease in GPHM equals a 10 percent reduction in fuel costs. On the other hand, *not all increases in MPG are equal*, although consumers erroneously expect them to be (Larrick and Soll 2008)<sup>2</sup>. A 10 percent increase in MPG does not correspond nicely to a reduction in fuel costs—it depends on what mileage you’re starting from. Suppose you drive 10,000 miles a year and a gallon of gas is \$2. Going from 10 MPG to 11 MPG is worth \$180, while going from 30 MPG to 33 MPG is only worth \$60.

The following graph illustrates the difference, using the same example of someone who drives 10,000 miles a year when gasoline is \$2 per gallon. For the same annual fuel costs, it plots the corresponding MPG and GPHM you would need. GPHM is a nice, straight function, a proportional relationship. MPG, on the other hand, is a relatively flat function at high costs, where small mileage increases save a lot of money, and a steep function at low costs, when big mileage increases save only a little bit of money. This fact turns out to be important not only for consumers but also for regulators.



## Reason 3: Pave the Way for CAFE Credit Trading

Current Corporate Average Fuel Economy (CAFE) regulations set an average fleetwide standard in miles per gallon. However, they do not use a simple average because, as we just saw, a one MPG increase means different things depending on whether it’s added to a small car or a big car. Instead, they use harmonic averaging, which is a complicated formula, but it ends up being equivalent to a standard set in gallons per miles, which is what we want when we care about fuel costs. (The harmonic average is calculated by taking the reciprocal of the average of the reciprocals of the fuel economies of the vehicles in the fleet. To parse

<sup>2</sup> See also [www.mpgillusion.com](http://www.mpgillusion.com).



that out, the reciprocal of MPG is GPM. So CAFE takes the simple average of the GPM of the fleet, and then takes the reciprocal again to convert that average back to MPG.)

So why change, if it means the same thing? Because it doesn't mean the same thing for companies that fail to meet the standard. Currently, that mainly applies to some luxury car companies like Porsche and BMW who pay fines rather than meet CAFE standards, because they don't sell small fuel-efficient cars to balance out their powerful cars. While the average citizen may not sympathize with luxury car owners or dealers, the point is that the policy isn't as effective at reducing fuel consumption. Some economists at the Federal Trade Commission have shown that, because of the harmonic averaging rule, for these kinds of manufacturers, selling an additional fuel efficient vehicle can actually result in a higher CAFE fine (Tenn and Yun 2005). That means the regulation is actually discouraging some sales of more fuel efficient vehicles.

Under current CAFE rules, the vast majority of vehicle sales are by manufacturers meeting their fleetwide averages. However, the Energy Independence and Security Act of 2007 set the stage for allowing CAFE credits to be traded across manufacturers.<sup>3</sup> The idea is to allow automakers for whom it is more expensive to comply with CAFE, perhaps because they have a comparative advantage in the large-vehicle segment of the market, to purchase excess credits from manufacturers for whom it is inexpensive to overcomply, rather than forcing large-car manufacturers to sell small cars their customers don't want. Both companies would benefit from the exchange of credits: the purchaser would have lower compliance costs, and the seller would profit from the sale and have extra incentive to improve its fleet's fuel economy even further. (See Fischer and Portney 2004).

However, to implement trading in CAFE, we need to calculate the appropriate number of credits to buy and sell. Suppose CAFE credit requirements were determined in the same way as the current civil penalty, under which a manufacturer is liable for each 0.10 MPG its fleetwide average falls below the standard, multiplied by the number of vehicles sold in a given model year. We see from the graph that as average MPG goes further and further below the standard, the increase in fuel costs gets bigger and bigger, but the increase in the credit liability (or fine) stays the same. Similarly, if a manufacturer exceeds the standard, its excess credits would increase the same amount with every 0.10 MPG increase, but the corresponding fuel savings would get smaller and smaller. Let two manufacturers trade, then, and we see a bigger increase in fuel costs from the credit purchaser than the decrease from the seller.

In other words, just as all MPG increases are not equal, all differences in harmonic MPG averages are not equal. So, to be correct in meeting a nationwide fuel economy standard, we'd need a harmonic average of all the manufacturers' harmonic averages. Of course, dedicated EPA regulators, auto manufacturers, and traders would be able to figure out those complicated formulas, but there's a much easier and more transparent way.

Instead, all we have to do is switch to GPHM, and all fuel consumption is treated the same. We can use a simple average to calculate manufacturer averages, and we can use the simple difference between that

<sup>3</sup> "The Secretary of Transportation may establish, by regulation, a fuel economy credit trading program to allow manufacturers whose automobiles exceed the average fuel economy standards prescribed under section 32902 to earn credits to be sold to manufacturers whose automobiles fail to achieve the prescribed standards such that the total oil savings associated with manufacturers that exceed the prescribed standards are preserved when trading credits to manufacturers that fail to achieve the prescribed standards." (Sec. 104 (f))



average and the standard to calculate the number of credits per vehicle a manufacturer can buy or sell. Then the fuel cost increases by the credit purchasers are exactly offset by the fuel savings from the sellers. We'd know we're hitting our national targets, and we'd be giving every manufacturer the same opportunity and incentive to innovate and improve the fuel economy across all of its passenger cars and light trucks.

This is an arcane problem. It was initially hard for me to grasp, so I've included the mathematical reasoning in the appendix. But the solution is so simple. Let's turn CAFE on its head and put our focus on the costs of fuel consumption—and then we'll see how far we can go.

## References

Fischer, C. and P. Portney. 2004. Tradable CAFE Credits, in *New Approaches on Energy and the Environment: Policy Advice for the President*, edited by Richard D. Morgenstern and Paul R. Portney. Washington, DC: RFF Press.

Huff, Darrell, Kristy Maria Huff, and Carolyn R. Kinsey. 1999. *The Complete how to Figure it: Using Math in Everyday Life*. New York: W.W. Norton & Company.

Larrick, Richard P. and Jack B. Soll. 2008. The MPG Illusion. *Science* 320 (June 20, 2008): 1593–1594.

Tenn, Steven and John M. Yun. 2005. When adding a fuel efficient car increases an automaker's CAFE penalty. *Managerial and Decision Economics* 26: 51–54.

Tenn, Steven and John M. Yun. 2007. On the Disincentive to Sell an Additional Fuel Efficient Light Truck under the Revised CAFE Regulation. Available at SSRN: <http://ssrn.com/abstract=985540>.

## Appendix: CAFE Math

CAFE standards require that each fleet meet or surpass a harmonic average for fuel economy, measured in miles per gallon, for the vehicles of that type. (Let's ignore the new size-based standards for light trucks; they complicate the math but do not change the fundamental problems with the MPG standards; if anything, they may exacerbate the problems. [Tenn and Yun 2008]) In other words, if  $q_i$  is the sales quantities of vehicles of model  $i$  with mileage  $MPG_i$ , CAFE standards mandate that for each fleet of autos

the harmonic average be higher than the standard, or  $\frac{1}{\sum_i \frac{q_i}{MPG_i} / \sum_i q_i} \geq MPG^*$ . We can rewrite this

requirement as  $\frac{\sum_i q_i}{MPG^*} \leq \sum_i \frac{q_i}{MPG_i}$ , or (with a little more rearranging and adjusting both sides by



100)  $GPHM^* \geq \frac{\sum_i GPHM_i q_i}{\sum_i q_i}$ . Thus, this requirement is equivalent to mandating that the average fuel consumption rate for the fleet be below the corresponding standards.

The tricky part comes when thinking about deviations from the standard, as would be allowed by CAFE trading. Because companies would not be individually required to meet the standard, their fleet MPG (harmonic) averages will vary. I discussed how credits for sales by above-average MPG manufacturers would not fully offset the increased fuel use from sales by below-average MPG manufacturers. But there exists the additional question of the incentives that system would create for improving and selling more fuel-efficient vehicles. Using MPG-based credits would spawn the same kind of problems as for the manufacturers facing CAFE fines. With a market for credits, all manufacturers will face the same credit price, much like a fine (except sellers collect the fine). To illustrate the effect on sales incentives, let us reframe the analysis by Tenn and Yun (2005).

Suppose a manufacturer's CAFE credit liability  $L$  is defined the same way as with the civil penalty:

$$L = \left( MPG^* - \frac{\sum_i q_i}{\sum_i \frac{q_i}{MPG_i}} \right) \sum_i q_i$$

How does this liability change with additional sales of vehicle model  $i$ ? That turns out to be a complicated function of all the different fuel economies and sales quantities:

$$\begin{aligned} \frac{\partial L}{\partial q_i} &= MPG^* - 2 \frac{\sum_i q_i}{\sum_i \frac{q_i}{MPG_i}} + \left( \frac{\sum_i q_i}{\sum_i \frac{q_i}{MPG_i}} \right)^2 \frac{1}{MPG_i} \\ &= (MPG^* - A) + (A / MPG_i - 1)A \end{aligned}$$

where  $A$  is the harmonic fleet average. If we convert this into GPHM, it is no simpler:

$$\frac{\partial L}{\partial q_i} = 100 \left( \frac{1}{GPHM^*} + \frac{\sum_i q_i}{\sum_i GPHM_i q_i} \left( \frac{GPM_i}{GPM^*} - 2 \right) \right)$$

The change in liability depends not only on that model's fuel consumption rate compared to the standard, but also total sales of that model and all the other models and their fuel economies.



Meanwhile, suppose the liability were defined instead in terms of the deviation in GPHM from a standard:

$$\begin{aligned}\hat{L} &= \left( \frac{\sum_i GPHM_i q_i}{\sum_i q_i} - GPHM^* \right) \sum_i q_i \\ &= \sum_i (GPHM_i - GPHM^*) q_i\end{aligned}$$

The change in the credit liability from additional sales of model  $i$  is then a constant and simple function of the difference in the fuel consumption rate from the standard for that model, and that model alone:

$$\frac{\partial \hat{L}}{\partial q_i} = GPHM_i - GPHM^*$$

The liability goes up if that model has an above-average fuel consumption rate, and it goes down if it's relatively fuel efficient.

The GPHM metric also makes it easier to incorporate size-based standards ( $SB$ ), in which the fuel economy standard varies by model  $i$ :

$$\hat{L}_{SB} = \sum_i (GPHM_i - GPHM_i^*) q_i$$

Again, the liability from additional sales only depends on the difference between actual and target fuel economy for that vehicle.

For harmonic averaging, however, incorporating size-based standards only makes the liability determination more complicated and less likely to produce an efficient outcome:

$$L_{SB} = \left( \frac{\sum_i q_i}{\sum_i \frac{q_i}{MPG_i^*}} - \frac{\sum_i q_i}{\sum_i \frac{q_i}{MPG_i}} \right) \sum_i q_i$$

Switching from MPG to GPHM will make CAFE regulations easy for anyone to understand and also allow for efficient credit trading and decisionmaking, even with size-based standards.

