National Center for Sustainable Transportation

"Actual Results May Vary": A Behavioral Review of Eco-Driving Research for Policy Makers

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POLICY BRIEF

Issue

Policy making in the United States regarding automotive fuel economy (miles per gallon) starts with federal Corporate Average Fuel Economy (CAFE) standards. CAFE standards are enforced via a process that literally removes the driver from the vehicle; test vehicles are placed on a chassis dynamometer and put through a precise, computer-regulated sequence of speeds and distances. Results are communicated to new vehicle buyers via the Monroney sticker on every new passenger car and light-duty truck sold in the U.S. with this caveat: "Actual results may vary for many reasons, including driving conditions and how you drive and maintain your vehicle."

Taking advantage of this variability to maximize on-road fuel economy is often referred to as "eco-driving." Eco-driving may address other important policy goals, including reduced pollutant emissions, improved safety, and improved traffic flow. In this way, eco-driving is implicated in a far broader set of policies and therefore relevant to a wide array of policy makers.

Policy Implications

There is a growing body of literature on the effectiveness of various eco-driving interventions. However, behavioral science is conspicuously absent from research that attempts to define, promote, and articulate the fuel savings potential of eco-driving. Therefore, when comparing and designing eco-driving policy interventions, policy makers need to carefully parse eco-driving functions, forms, and contexts (i.e., what behavior is to be enacted, by whom, in what context, and to accomplish what function).

Further, policy makers need to consider safety implications in eco-driving promotional programs. Such multi-function designs (e.g., fuel use reductions and improved safety) guard against the potential excesses of hypermiling (e.g., drafting too closely behind other vehicles in order to improve fuel economy).

Until a robust research agenda emerges to test the best forms of interventions, driver feedback mechanisms can be designed according to established principles and empirical results. We suggest feedback design include: 1) real-time ambient indicator(s) of what a person is to do (rather than what a vehicle is to do), 2) a comparison to a driver-salient goal, and 3) standardized iconography.

Just as fuel, engine, and headlight indicators have internationally recognized icons, standardized eco-driving feedback mechanisms would help drivers to more easily adopt eco-driving behaviors across different vehicles. Since in-vehicle displays (for eco-driving or other purposes) are becoming increasingly complex and concerns about driver distraction are growing, standardized eco-driving feedback mechanisms may be coming sooner rather than later (Figure 1).

Finally, providing support for eco-driving research grounded in behavioral science will allow a basis for generalization and improved intervention design. It is crucial to understand why, how, and for whom a given strategy works to avoid over-generalizing and missing the key ingredients of effective eco-driving policies.

Research Findings

Eco-driving is a means to achieve multiple goals of personal and societal importance: financial savings, reduced fossil fuel consumption, reduced greenhouse gas emissions, and improved air quality. However, eco-driving has been defined
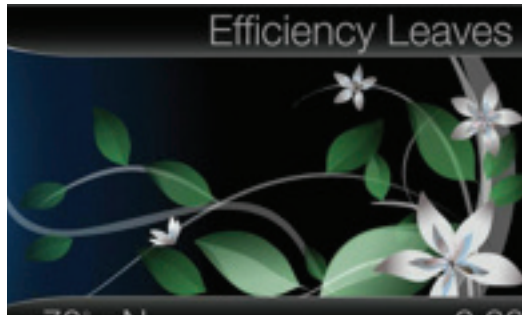
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Figure 1: Energy use and fuel efficiency displays are becoming more prevalent in vehicles, especially hybrids and electric vehicles. The above images provide an example of a simple numeric display of fuel economy as well as a more elaborate, graphic display of fuel economy. The level of variety indicates either a belief in a competitive advantage on the part of the vehicle manufacturer or, as seems more likely, a lack of a basis for deploying standardized feedback principles.

inconsistently. Definitions in both academic and popular sources can be imprecise and contradictory. For example, the literature variously recommends that drivers accelerate "gently" or "moderately" or "quickly" to "desired speed."

Based on a synthesis and critique of definitions, we conclude eco-driving should be defined as exactly those behaviors the CAFE test procedure assumes away. We classify eco-driving behaviors as a six-dimensional suite including 1) **driving** (efficient accelerating, cruising, decelerating, waiting, and parking); 2) **cabin comfort** (climate settings, ventilation, and use of other auxiliary electronics); 3) **maintenance**; 4) **fueling**; 5) **load management**; and 6) **trip planning**. We exclude vehicle purchase decisions and travel mode choices.

How much energy or emissions intensity can be reduced depends on how many of these behaviors are enacted and evaluated. We reviewed 40 studies; 32 assessed fuel economy. Outcomes spanned from increases to decreases in fuel economy; average savings were about 9%. This savings estimate only reflects the effectiveness of the eco-driving behaviors targeted in the studies. Driving behaviors (largely to the exclusion of maintenance, trip planning, etc.) were the most frequently targeted. Because this estimate of savings potential and estimates from other reviews are based on only a subset of eco-

driving behaviors, typically within only one of the six dimensions (driving), it appears the savings potential of eco-driving is substantial (i.e., more than 9%).

The 9% average savings across studies reviewed also only reflects the effectiveness of the strategies used in those studies. In-vehicle feedback was the most prevalent strategy. From the existing literature it is difficult to determine how eco-driving feedback works and for which behaviors, thus it is not yet possible to determine the most effective types of feedback. There are two reasons for this difficulty: 1) studies of in-vehicle feedback range widely in terms of the information conveyed to drivers and feedback design; and, 2) most studies compare one type of feedback to nothing rather than comparing multiple types of feedback to each other. The few comparative studies suggest feedback is more effective when it aligns with the driver's goals, such as to get around faster, drive safely, save fuel, save money, reduce emissions, or drive less, and when it is adaptive, i.e., consisting of graduated challenges based on improvements in performance.

We conclude that systematic empirical research is still required to determine precisely the most promising eco-driving behaviors to target and the most effective driver feedback to promote those behaviors. Further, manufacturers are generally providing more feedback and more sophisticated feedback designs in hybrid and electric vehicles than in conventional gas-fueled vehicles (Figure 1). While this makes some sense from a marketing perspective, there seems to be ample opportunity for the inclusion of feedback in conventional gas-fueled vehicles to help achieve policy goals.

Further Reading

This policy brief is drawn from the full report, "'Actual Results May Vary": A Behavioral Review of Eco-driving Research for Policy Makers," Ken Kurani, Angela Sanguinetti, & Hannah Park, which can be found at: bit.ly/EcoDriveLDV