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Eco-driving: An overlooked climate change initiative

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ABSTRACT

The actions individuals can take to mitigate climate change are, in the aggregate, significant. Mobilizing individuals to respond personally to climate change, therefore, must be a complementary approach to a nation's climate change strategy. One action item overlooked in the United States has been changing driver behavior or style such that eco-driving becomes the norm rather than the exception. Evidence to date indicates that eco-driving can reduce fuel consumption by 10%, on average and over time, thereby reducing CO_2 emissions from driving by an equivalent percentage. A sophisticated, multi-dimensional campaign, going well beyond what has been attempted thus far, will be required to achieve such savings on a large scale, however, involving education (especially involving the use of feedback devices), regulation, fiscal incentives, and social norm reinforcement.

1. Introduction

The United States is poised to establish a new regulatory regime for the purpose of reducing greenhouse gases (GhGs). All indications are that this regime will revolve around a cap-and-trade system whereby large emitters (electric utilities and industries) will be required to reduce emissions in the aggregate over time. The regime will not touch individual citizens directly, but will, of course, impact them through the actions taken by large emitters.

While it is probably premature to spin the regulatory web around individuals, it is not too early to seek to fully engage citizens in the unprecedented challenge of reducing GhGs, and thereby preventing dangerous climate change. It is too late to prevent climate change, but it is not too late to prevent *catastrophic* climate change if we fully engage all sectors of society. Autonomous individual actions need to be seen as a necessary complement to the cap-and-trade system being put in place, rather than being simply tangential to it.

The focus of this article will be personal transportation, specifically automobile and light duty vehicle (hereafter referred to as cars) use and the opportunity to engage the public in climate-friendly behavior. There are several ways individuals can reduce their GhGs associated with personal transportation: they can purchase more fuel efficient vehicles; they can purchase vehicles that utilize low-carbon fuels (e.g. electricity, natural gas, or ethanol); they can reduce their vehicle miles travelled through such actions as carpooling and use of public transportation; and, they can operate their current vehicles more efficiently. Attention will be given to the latter as it is frequently overlooked and/or thought difficult to achieve. It will be seen that the potential for positive change is actually large if we put into place a sophisticated and well-funded campaign involving state-of-the-art education, feedback mechanisms, economic incentives, regulations, and multi-dimensional, norm-changing practices.

2. Direct, individual actions

While each individual's actions result in trivial GhG emissions, the results are hardly insignificant when viewed in the aggregate, across the entire population. Studies (Vandenbergh and Steinemann, 2007; Vandenbergh et al., 2008; Bin and Dowlatabadi, 2005) have shown that behaviors that are substantially and directly controlled by individuals—i.e. personal transportation and household energy use—constitute anywhere from 32% to 41% of total carbon dioxide (CO_2) emissions (with CO_2 being the primary GhG by far). Even if we take the low end of this range, we are talking about over two billion metric tons of CO_2 or roughly 8% of the world total. This exceeds all of the emissions emanating from the industrial sector, and is larger than the total emissions from every country other than China (Marland et al., 2008). Direct, individual energy use (and consequent CO_2 emissions) consists of household energy use and personal (non-business) transportation. Recent studies (Ehrhardt-Martinez, 2008; Gardner and Stern, 2008; Dietz et al., 2009) indicate that energy reductions of 20–25% are feasible in households while maintaining the existing standard of living and even producing net household savings.

While the potential emission savings from engaging the public in GhG-reduction activities are huge, policymakers have, thus far, been reluctant to tackle them head-on. First, the importance of engaging the public directly in GhG-reduction activities is not well understood, either by the general public or policymakers. The

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frame of reference still appears to be the pollution model whereby pollution is associated with large-scale emitters and not single individuals. Individuals are unlikely to engage in emission reduction activities if they feel that major emitters have "not done their part." Another complication is a pervasive skepticism regarding climate change amongst a certain segment of the population. This is made possible, despite overwhelming scientific consensus, by the invisible nature of GhGs and their uncertain or distant impacts to date.

Adding to the conceptual barrier is a deep-seated skepticism about the ability to change individual behavior at acceptable levels of cost and intrusiveness (Vandenbergh, 2005). The skepticism is fueled by a limited understanding of the lessons from prior research and experience. Individual behavior is undoubtedly difficult to change, and prior efforts to use taxes and command-and-control requirements to reduce pollution from individual behavior have been very unpopular. Although sophisticated efforts that have combined social, economic, and legal incentives have led to changes in a wide range of individual behaviors (e.g. littering, recycling, second-hand smoke, seat belt use, and baby safety seat use) the relevance of these behavior change campaigns to energy is not always clear, and important areas of uncertainty exist. As such, policymakers often fail to incorporate the lessons of existing research into the design of new measures. Attempts to change behavior in the 1970s and 1980s in response to the perceived energy crisis were mixed, at best (Wilhite et al., 2000). Perhaps the most enduring image is that of President Carter wearing a sweater while preaching to the public about the virtues of sacrifice in the form of lower indoor temperature thermostat settings. No political figure wants to revive that disastrous political strategy.

The good news, however, is, first, that many significant emission reduction activities do not entail sacrifice (doing without or doing with less); rather, they involve the one-time purchase of major energy efficient technologies that will save the individual money over the long term. And, the barrier of high initial costs can be overcome, to some extent, by financial incentives. Second, even when behavior change is required, as opposed to consumer purchases, we know a great deal more today about the kind of measures that need to be combined to produce the desired end result. This does not mean that any measured policy intervention will be guaranteed, since custom, habit, and engrained beliefs are still formidable barriers to change. But it does mean that policymakers need not, *a priori*, remove behavioral approaches to climate change from active consideration.

3. Personal transportation measures

The potential for cost-effective emission reductions within personal transportation is large. Most of it involves personal vehicle purchases and operation since nearly 90% of the emissions associated with personal transportation today emanate from these vehicles. And, personal vehicle emissions are the largest single contributor to household/individual emissions.

Gardner and Stern (2008), as well as others, highlight the significance of purchasing higher efficiency cars, and, indeed, this is the first measure that comes to mind in the consideration of policy options. Large savings are possible because our current fleet of cars is relatively fuel inefficient, since car producers over the past two decades have increased car horsepower and size at the expense of fuel efficiency (USEPA, 2008). The Energy Independence and National Security Act of 2007 raised mandatory fuel efficiency standards for the first time in three decades, and even more rigorous fuel economy requirements are expected based on likely federal approval of California's CO_2 tailpipe standards. Hence, we can expect the entire fleet of cars to become much more efficient over time. But, unfortunately, it will take time. Due to the major expense of purchasing a car, only about 7% of our vehicles are replaced in a single year (ORNL, 2008), making improvement very gradual and incremental.

Besides being more fuel efficient, many new vehicles will utilize low-carbon fuels. Indeed, we have just begun a major transformation whereby electrons will replace petroleum as the desired fuel in cars (Barkenbus, 2009). But again, this transformation will be gradual.

Reducing the vehicle miles travelled in cars is the next option that normally surfaces when contemplating emission reductions. Means of doing so involve such things as carpooling, greater use of mass transit, more efficient planning of local trips, and household relocation to more urban surroundings. Potential savings from getting people out of their cars, or at least in the habit of sharing their cars, are not trivial. Unfortunately, however, efforts to do so to date have met with considerable resistance except in high-density communities.

Perhaps the most overlooked action that could garner significant CO_2 savings is simply the alteration of current driving styles. That is, a change from an "aggressive" driving style to a more refined style, frequently referred to as eco-driving. The advantages of this option are that savings can be immediate across the entire car fleet (including fuel-sippers and SUVs); savings accrue to both the individual and society at large; and, few, if any, purchases would be required to achieve the desired result. Disadvantages, of course, are little public understanding of the nature of eco-driving, and seemingly ingrained driving habits. The balance of this paper is devoted to exploring this option and formulating the elements of a campaign that could overcome initial resistance.

4. Eco-driving

The characteristics of eco-driving are generally well defined and easily characterized. They involve such things as accelerating moderately (with shift ups between 2000 and 2500 revolutions for those with manual transmissions), anticipating traffic flow and signals, thereby avoiding sudden starts and stops; maintaining an even driving pace (using cruise control on the highway where appropriate), driving at or safely below the speed limit; and eliminating excessive idling. Some eco-driving advocates include automobile maintenance measures, such as maintaining optimum tire pressure and the regular changing of air filters, in their definition of eco-driving. But for the purposes of this paper we will be dealing solely with driving behavior. The advantages of eco-driving, of course, go beyond CO_2 reductions. They include reducing the cost of driving to the individual and producing tangible and well-known safety benefits (with fewer accidents and traffic fatalities).

Eco-driving should be distinguished from *hypermiling*. While they can share the same goal of reducing operator cost of the vehicle, they differ in terms of tactics. Hypermiling (Chapnick, 2007) often involves coasting down hills (turning the ignition off) and drafting by getting as close to the vehicle in front of you as possible. Clearly hypermiling trades off safety for fuel economy, while with eco-driving there is no tradeoff.

As can be seen, eco-driving is simple to understand, and there are an abundance of websites that promote and distinguish eco-driving as a tool for reducing an individual's carbon footprint (Alliance to Save Energy, 2008; Siuru, 2008; Alliance of Automobile Manufacturers, 2008; Ecodrive.org, 2009). Moreover, eco-driving, as noted earlier, can be a win–win proposition for both individuals (through cost savings and greater personal safety) and society (through reduced CO_2 emissions, reduced petroleum imports, reduced emissions of conventional pollutants, and fewer fatalities). Nevertheless, there are still cultural, technical, and educational barriers inhibiting its adoption. Cars are more than simply a means of transportation to many, and are sometimes prized for capabilities that run counter to prudent eco-driving principles. Horsepower and acceleration are key examples. Over the past 30 years automakers have decreased the time it takes for a car to accelerate (typically measured in how quickly it can go from 0 to 60 miles per hour) by greatly increasing average car horsepower (USEPA, 2008). Increased horsepower also allows for comfortable high-speed operations on major highways, much to the detriment of fuel economy. Considerable advertising to consumers is still predicated on acceleration and horsepower. Is it any wonder, therefore, that upon purchase of these vehicles that Americans seek to maximize these features? Moreover, surveys have shown that a large majority of Americans still believe that cars must idle for minutes to achieve optimum operating conditions, when, in fact, only a few seconds are necessary and appropriate (Carrico et al., 2009). Considerable gasoline, therefore, is combusted unnecessarily.

There is no existing federal government program to promote eco-driving. This was not always the case, however. In the late 1970s, the Department of Energy (DOE) established the Driver Energy Conservation Awareness Training (DECAT) program (DOE, 1980). It targeted large fleets and motor pools, but also intended to reach the general public. Officials from state governments and other large organizations could travel to the DOE Nevada Operations Office where, over a period of a few days, they were trained in fuel efficient driving techniques. By the mid-1980s over 8000 people had been trained, and returned to disseminate their knowledge broadly. The program, however, was terminated in the late 1980s, the victim of public indifference (because of low gasoline prices) and the Reagan Administration's de-emphasis of energy issues.

Even while the United States has abandoned eco-driving programs, several European countries and Japan have incorporated them within their national CO_2 reduction strategies (International Transport Forum, 2007a). Under European Union regulations, eco-driving is required to be incorporated into introductory driver education classes across Europe. High motor fuel prices, of course, add an additional incentive for promotion and interest.

The eco-driving efforts across Europe are targeted to existing drivers and vary in their programmatic offerings. They usually involve high-visibility public relations campaigns, sessions devoted to driver training, and collaboration with commercial sponsors. Eco-driving training consists of such things as train-the-trainer sessions, employer-targeted campaigns, and individualized training at special events (such as motor shows or eco-day celebrations). There tends to be an element of "edutainment" with the inclusion of driver competition and prizes. Heavy emphasis is given to demonstrating before and after fuel efficiency results from individualized training. Sponsorship of these events, as well as the training, is frequently carried out by private entities, such as Ford Motors/Europe and BP. Eco-driving program directors claim that CO_2 reductions can be had both quickly and cost-effectively from eco-driving programs (International Transport Forum, 2007b). The Dutch, for example, claim that costs are 7 euros (roughly \$10) per metric ton of CO_2 is avoided (van den Berg, 2007).

5. Savings from eco-driving

A reconstitution of the United States program would be advisable if the CO_2 reductions that can be achieved from eco-driving are significant. The question of how much energy can be saved realistically through eco-driving is still subject to debate. One can find claims of 25% improvements in fuel economy during short-term, contest, situations (Ford, 2008). We are more interested, however, in sustained, normal, driving practices, and in this case fuel savings are conservatively calculated at 5% where there is no support beyond initial training and 10% when there is continuous feedback (both training and feedback are discussed in subsequent sections of this paper) (International Transport Forum, 2007b). The 10% figure from recent programs is consistent with estimates made in the earlier DECAT program (Greene, 1985).

A recent pilot project in Denver tracked the driving performance of 400 participating cars, through the use of on-board telemetry devices, with data then being transferred to computers for analysis. It also showed that a driving improvement of 10% was being achieved through this education and monitoring effort (Enviance, 2009).

In 2005, approximately 428 billion liters (113 billion US gallons) of motor fuel were combusted in cars owned by households (DOE, 2008). A 10% reduction, therefore, would amount to a savings of 42.8 billion liters. A liter of gasoline when combusted emits 2.31 kilos of CO_2 to the atmosphere, so if we multiply the 42.8 billion liter savings above by this number, we get CO_2 emission reductions of close to 100 million metric tons. This might be viewed as the total technical potential derived from eco-driving in the United States.

This assumes that no one is currently driving in an eco-driving fashion, and that we can persuade everyone to convert to such driving in the future. Both assumptions are unreasonable. We frankly do not know how many drivers are currently eco-drivers or how many of the non-eco-drivers can be enlisted. Perhaps a conservative assumption would be one-third of all US drivers making a change to eco-driving, thereby achieving an annual savings of 33 million metric tons of CO_2. These savings are independent of those associated with proper car maintenance, a feature that would no doubt be emphasized in any future eco-driving campaign. To put this in perspective, it is the equivalent of 2/3 the annual emissions of the aluminum industry in the United States (Schipper, 2006), and equivalent to eliminating seven large coal-fired electricity plants, or taking nearly 6 million cars off the road (USEPA, 2009). The savings would be even more dramatic if eco-driving became a well-established norm amongst all drivers.

We can also calculate the savings to households. If we take a third of 42.8 billion liters of gasoline (14.1 billion) and multiply that times the price of gasoline (say, either \$0.53 or \$1.06 per liter) we get an aggregate societal savings of \$7.5–15 billion. Dividing this total by a third of all households (35 million), we get an average household savings ranging from \$214 to \$428 per year.

These results are significant and with the evolving nature of the automotive fleet, they are destined to become even more important in the future. It is likely that hybrid cars (i.e. those using both electricity and motor fuel to propel the vehicle) will become increasingly prominent. The fuel economy of hybrid cars is extremely sensitive to driving behavior. Aggressive driving, which fails to take advantage of the hybrid's regenerative braking system, can reduce fuel efficiency by more than 30% (Romm and Frank, 2006). Those seeking hybrids for better fuel efficiency, therefore, may have to learn a completely new way of driving if they expect to achieve their aim. The transition to hybrid-electric vehicles opens a real window of opportunity for eco-driving advocates, therefore, as drivers will attempt to obtain maximum fuel efficiency in their new vehicles. Automakers seeking to interest the public in purchasing hybrids will be natural allies in a future eco-driving campaign.

6. Changing behavior and engaging the public

Probably most Americans are unaware that their driving style can significantly affect vehicle fuel efficiency. Consumers may be aware of fuel efficiency estimates, derived through Environmental Protection Agency (EPA) tests and posted on new vehicles, but they are unlikely to know that the appropriate measure is really a range of numbers and not a fixed point. Considerable educational effort, therefore, is both justifiable and necessary. Simply the transfer of this knowledge by itself, however, is unlikely to lead to changes in driver behavior. Overcoming driving habits engrained through many years of practice, is not simple.

Based on behavioral research of the past few decades (Abrahamse et al., 2005; Stern, 2000) it is clear it will take a well thought-out, and well-funded, *combination* of interventions to achieve the desired result. This means that single-instrument policies—commonly manifest as low-cost, public education campaigns—are unlikely to achieve policy goals. Any eco-driving strategy in the US must go well beyond the eco-driving efforts highlighted thus far in Europe. If we are to truly engage the American public in eco-driving, therefore, a sophisticated, multi-dimensional campaign involving education, regulation, fiscal incentives, and social norm reinforcement must be mounted. Thoughts on possible desirable elements within each policy category are discussed in the following sections.

6.1. Public education policy

Though insufficient in itself, education provides the essential bedrock on which an intervention process rests. As noted previously, there are a number of websites individuals can turn to for information about eco-driving. The good news is that they provide fairly uniform information on the characteristics and potential benefits from eco-driving. The bad news is that only those individuals already motivated to change their driving behavior or reduce their carbon footprint in general will go to the websites. They will not, therefore, trigger the scale of the effort ultimately desired.

An interesting public education campaign for eco-driving was launched during the summer of 2008 by the Alliance of Automobile Manufacturers (2008). Though the campaign's website contains useful information for the individual driver, it appears clearly targeted to state and local governments. It provides a list of 13 actions state and local governments can take, ranging from simply posting information about eco-driving on government websites, to making sure that eco-driving is incorporated within school-based driver education programs. When launched, the campaign highlighted the support of the governors from California and Colorado. Unfortunately, no other state governments have signed up for the program to date, and it is not even clear what the commitments from California and Colorado constitute other than rhetorical support.

All of the European countries engaged in eco-driving programs have launched multi-media communication campaigns, seeking to portray eco-driving in a favorable light. Emphasis is placed not on CO_2 savings, but rather on cost savings, accident prevention, and lifestyle decisions. Invariably they are seeking to brand eco-driving, providing attractive and even humorous images to a younger generation on the basis of lifestyle and cultural attractiveness. The picture below is taken from the Dutch eco-driving campaign (Wilbers, 2007) which uses popular Dukes of Hazzard images to sell the practice (ironic because the portrayal of driving in the Dukes of Hazzard television show was hardly a paragon of desirable eco-driving practices). Some different, but comparable image in terms of modern lifestyles would have to be used in an American eco-driving campaign.

6.2. Feedback

Perhaps the most important educational element in changing driver behavior is the positive feedback from taking the desired action. The absence of positive feedback or reinforcement from energy conserving actions in general has been a familiar lament for decades (Seligman and Darley, 1977; Sexton et al., 1987). Behavioral theory strongly confirms that unless the individual can see or feel the results of his/her actions—preferably on an immediate and continuous basis—that individual is unlikely to maintain the behavior over time. The individual components of eco-driving are so small that unless feedback on the collective effort is provided, the driver is unlikely to perceive important changes in fuel economy. As noted previously, a strong eco-driving program in the absence of feedback might lead to a 5% increase in fuel efficiency; but with feedback, this increase could double. The considerable importance of continuous feedback to the achievement of eco-driving goals has been known for some time. In a report produced over 20 years ago, Greene (1985) stated "What is required is a device that gives the driver immediate and accurate fuel consumption information, yet is not a distraction from safe driving." He recommended that considerable research into these devices be undertaken to produce simple and inexpensive devices.

The good news is that with advances in microprocessors, accurate and inexpensive devices measuring and displaying fuel use are available today, and many automakers appear committed to installing them on at least some of their models. The company displays all differ somewhat in their features, but they all have the purpose of providing instant feedback to the driver of the vehicle's fuel economy performance. They have first appeared as features of hybrid-electric vehicles, probably because the driving habits of the public are very important in the achievement of advertised fuel economy levels. Since better fuel economy is the primary selling point for these vehicles, the importance of these devices is well understood.

Experience to date indicates that drivers welcome feedback devices in their vehicles, and alter their driving habits as a consequence. Many will even attempt to make a game out of it, seeking ways of driving that maximize fuel savings (Kurani, 2007).

Not surprisingly, the best selling hybrid-electric vehicle, the Toyota Prius, has garnered most of the attention for its multi-information display mounted prominently at the center of the dashboard. The driver can receive fuel economy information from three different displays (in the most current model): an immediate mile per gallon (mpg) figure; a 5 min average mpg; and, a trip duration mpg. Other Toyota hybrids have comparable displays, and the company has committed to installing them in all Toyota vehicles—both hybrid and non-hybrid—in the future (Toyota, 2008).

Some of the newest hybrid-electric vehicles coming to market not only provide driver feedback, but also establish driving parameters for the vehicle that can assist in eco-driving. Honda, for example, is installing in its Insight hybrid, designed as a direct competitor to Prius, a driver-activated ECON mode that adjusts vehicle performance characteristics to the most fuel efficient operation. This includes energy savings control of the air conditioner, engaging the idle stop sooner, and maximizing regenerative braking. Not to be left behind, Toyota, in its 2010 Prius has a comparable Eco-Mode category, as well as an EV Drive Mode that allows for only battery operated propulsion for one mile. Drivers have the option of choosing these operating modes at the push of a button.

Feedback displays are still featured prominently in these newer vehicles. Honda (2009) is installing what it calls the Eco Assist dashboard in its Insight. The Eco Assist display provides the driver with an assessment of how successful he/she is in achieving maximum fuel economy performance by the use of a simple color-coded system and through the portrayal of graphic ''leaves'' (the more leaves the better). It also allows drivers to view fuel economy numbers on an instantaneous basis as well as over the duration of an entire trip.

Ford will be mounting what it calls its Smart Gauge with Eco-Guide on its new Ford Fusion and Mercury Milan hybrids (White, 2009). This monitoring device is placed in front and center of the driver and allows the driver to select the level of monitoring detail desired. With selection of the more detailed levels, the driver can get average miles per gallon numbers, a color-coded leafy display of eco-driving performance (similar to the Honda system) and mileage history.

While the monitoring displays just mentioned may be the most current and elaborate feedback devices for vehicles, there are other options as well. Some Nissan vehicles are being equipped with a ''fuel efficiency'' meter, constituting a color-coded horizontal bar. The bar changes length and color depending on the driving behavior of the driver. Nissan has committed to equipping all of its vehicles with this tool as it phases in new models (Woodyard, 2007). Fiat also has an interesting twist, whereby the driver can attach a programmed flash drive (or USB key) to the vehicle's computer diagnostics station and after a trip, take the power stick to a computer where the driving behavior and fuel efficiency of the trip can be displayed. This is not quite as good as instant feedback, but it is a good educational tool.

The heavy emphasis on monitoring systems for hybrid-electric vehicles is understandable given, as noted previously, the significant importance of driver behavior or fuel economy in these vehicles. It would be wrong, however, to associate these monitors only with hybrid-electric vehicles. The vast majority of vehicles on the road today utilize standard, internal combustion engines, and driving behavior is critical to determining fuel efficiency in these vehicles as well. Monitoring devices are already on the market that can be attached to virtually any vehicle (made after 1996), the most prominent being the ScanGauge. This device can be mounted at the center of the dashboard, and, when connected, will give a numerical readout of instantaneous miles per gallon as well as fuel efficiency over the entire trip's duration. The ScanGauge (2009) can be purchased over the internet and retails for slightly above $150.

6.3. *Regulatory actions*

We cannot simply regulate eco-driving, but we can use regulatory tools as a complement to other public policy instruments. As noted previously, the European Union mandates the inclusion of eco-driving in beginning driver training courses. Such a directive from the US federal government is possible but would be in violation of a long-standing federalism principle that makes driver education a state-based prerogative. Fortunately, strong encouragement and assistance in the promotion of eco-driving from the federal government to the states would probably receive a welcome reception. Eco-driving principles are consistent and supportive of the safety thrust of today's driver training. New curricula recommendations, therefore, could probably be incorporated within existing training manuals with relative ease.

Another action the federal government could make would be to reduce speed limits on the interstates. Fuel economy decreases substantially at higher speeds. Research shows (Greene, 2008) that for each 5 mph (8 kph) above 55 mph (88 kph), fuel economy decreases by about 7%. The federal government imposed a 55 mph (88 kph) speed limit on the interstates in 1974, in light of the perceived energy crisis. This limit proved enormously unpopular, however, and was finally repealed in 1995. Consequently, most states raised their maximum state limits to either 65 or 70 mph (104–112 kph). Re-imposition of lower speed limits to 55 mph (88 kph) would likely prove very unpopular today, but this could change over time. A national standard of 65 mph (104 kph) might be more acceptable, particularly since the American Trucking Association has argued forcefully for such a standard (Hodges, 2009). What states could be encouraged to do, in any event, would be to establish better and more rigorous enforcement of existing limits. Interstate traffic routinely exceeds these limits, thereby endangering lives and wasting fuel simultaneously.

Still another possible regulatory measure would be the spread of anti-idling ordinances. Many states and localities have already passed ordinances that prohibit idling for more than 5 min, subject to fines ranging from $50 to $500 (ATRI, 2009). The purpose of such measures is not to create intrusive police monitoring or a revenue-generating program, but rather to create or reinforce a societal norm against undue idling. It would function, therefore, in a manner similar to how seat belt requirements function today.

As can be seen, the regulatory component of an eco-driving campaign would not be expected to do the ''heavy lifting'' required for its success. A heavy-handed, ''stick'' approach to eco-driving could easily backfire. Rather, regulations should serve as reinforcement for the more central elements of the effort dealing with ''carrots'' or incentives. We turn to those now.

6.4. *Economic policy or incentives*

A system of incentives must be constructed to have the desired effect, involving not only individuals, but employers and contractors. These incentives must be more than token since we have to overcome long-standing driving habits, reinforced by cultural norms and technology. Individuals would be the central focus of the incentive package, but incentives to institutions and organizations would be required as well to provide an environment conducive to individual acceptance.

Fundamentally, we need individuals to sign up for driver training focused on eco-driving. One can understand the principles of eco-driving simply from public education announcements, but performance can only be learned through actual driving experience.

There are a variety of training options possible. First might be training in conjunction with special events, such as ''earth day'' celebrations or motor shows. This training is a central feature of the European eco-driving programs, and has been led by such private entities as Ford Motor Company in the provision of training professionals. These 30–60 min hands-on training sessions, which Ford calls ''training snacks,'' bring individuals together with eco-driving professionals involving use of either a vehicle simulator or an actual vehicle. More recently, Ford has been working in association with United Kingdom agencies to offer eco-driving competitions at special events (Saynor, 2008). This involves offering prizes to individuals who demonstrate both the best results in fuel economy and those demonstrating the most improvement. Actual results from before-training and after-training driving form the basis for the awarding of prizes. Ford claims that event training normally results in an average fuel economy driving improvement of 25% (Hennig, 2008). Public–private partnerships are key to making these events possible.

Another model for training in the United States might involve collaboration between professional training associations and school-based driver education programs. One organization, the National Institute of Vehicle Dynamics (NIVD), is experimenting with this route to driver training by providing a 2-day weekend training session taking place on high school grounds. NIVD training is focused on emergency driving situations (NIVD, 2008), not eco-driving, but it provides a potential business model that deserves evaluation.

Still another possibility is being pursued by a joint venture between Ford and the ProFormance Group (based in Phoenix). It involves an intensive 4-day eco-driving course (Ford, 2008). A pilot project in Phoenix was carried out recently, with results showing a 24% average improvement in fuel economy (with a range 6–50%). It appears this more intensive training program is being targeted to owners of large fleets. Fuel savings aggregated over an entire fleet of vehicles and drivers could produce significant company or agency cost savings. On the face of it, companies with large fleets would have considerable incentive to bring in professional trainers if documented fuel savings are as large as now being touted.

Regardless of how driver training opportunities are made manifest, they should seek to obtain maximum public participation and, as such, should be offered *at no cost to individuals*. Regardless of the cost savings eco-drivers will gain over time, there will be considerable reluctance to participate in training if an upfront fee is required for attendance. This means that training sessions will have to be subsidized either by the public or private sector, or a combination of the two.

A particularly attractive incentive for widespread public participation might be a government offer to share the costs of a vehicle feedback device (as described previously) with each individual who has successfully completed a certified eco-driving training course. This is important not only because it is a tangible reward for completion of the course but because it addresses one of the key concerns observers have with eco-driving training; namely, that participants will relapse into older driving habits as time moves on. We know that the 25% efficiency gains often obtained in training sessions are not sustainable over the long term, and, as noted previously, a more reasonable estimate of long-term gain, absent any prompt, is approximately 5%. With a feedback device in place, however, serving as a daily reminder of eco-driving and actual fuel economy, a 10% savings in fuel economy is possible. Such devices as ScanGauge can be purchased individually for approximately \$150. Bulk orders for such devices should bring down costs considerably, perhaps to approximately \$100. A 50–50 cost share, therefore, would only require the driver to put out \$50; far less than one year's savings from eco-driving. The Dutch offered such devices free through its eco-driving program for a few years. The incentive was so popular that requests overwhelmed the budget allocated for distribution and the offer was subsequently terminated (International Transport Forum, 2007a, b).

Yet another incentive for public participation could be a reduction in vehicle insurance rates for those completing an eco-driving training course and demonstrating eco-driving performance on the road. An insurance company, Progressive Casualty Insurance Co., is already pioneering this system in a limited number of states under the MyRate label (McQueen, 2008). Those drivers willing to participate in this program install a device into the vehicle's diagnostic port (just as is done with the Fiat device mentioned previously) where it records miles travelled, speed, and how hard brakes are being applied. After 6 months the device is removed and the data are downloaded to a computer and forwarded to the insurance company. Progressive claims that the MyRate option can lead to insurance rates as much as 60% lower than average for the most conscientious eco-drivers (McQueen, 2008). A similar "pay how you drive" insurance program is being offered in England (GreenRoad, 2009).

As can be seen, there are a number of financial incentives that can be marshaled to engage and lure the American public into eco-driving. A dynamic public education campaign can highlight the very real cost savings associated with eco-driving; free training courses can be offered to teach drivers how to achieve the fuel efficiency gains from eco-driving; and, insurance policies can reflect the greater safety benefits from eco-driving, leading to lower rates for eco-drivers. Yet, even with all of these financial benefits considerable apathy is still likely simply because eco-driving adoption is not simply a matter of more education but also about changing long-standing and pervasive driving norms. If we wish to address norms directly we have to turn to social marketing.

6.5. *Social marketing*

We associate marketing with the sale of consumer products. But marketing can also be associated with the encouragement of behaviors that advance the social good. This so-called social marketing draws upon well-established social science theory and applications to achieve its aims. Social marketing to date has been primarily directed toward public health concerns (e.g. anti-smoking and obesity campaigns) but there is no reason to believe it cannot be utilized to promote eco-driving and the subsequent reduction in CO_2 emissions. The typical American tends to think of his/her own contribution to climate change as trivial. It is only when trivial actions are multiplied across the entire population that large impacts are achieved. Americans need to believe, therefore, that their eco-driving behavior is not a singular action, but rather one that is being undertaken by others across the country for the common good.

One of the most fundamental tools used in social marketing is to employ such traits as inclusiveness, competition, and goal achievement in the services of new behavioral norm creation. People want to feel part of a community or at least part of a movement that is gaining momentum into the future. We are beginning to see this develop, particularly with respect to household energy behavior. A television reality show in the Boston area, called "Energy Smackdown," pits homeowners against each other in a race to shrink their carbon footprints (Copeland, 2008). This form of competition provides an incentive to find ways to reduce energy without impairing the quality of life. And, through the power of the medium, these lessons are passed along to many others. Competition is also inherent in the social-marketing tool provided electric utilities by a firm called Positive Energy. Under this framework, Positive Energy identifies electricity usage of households according to comparable housing size and community. It then sends a notice to each household informing occupants of where their house ranks on the spectrum of electricity usage. Since electricity usage, normalized by house size, can differ by a factor of three (Lutzenhiser, 2007), there is considerable potential for most occupants to take significant actions that will bring them closer to the most efficient end of the spectrum. In the letter to occupants describing the household's relative ranking to others, Positive Energy provides energy-saving tips that occupants can adopt to improve their relative ranking. Evaluations to date show that many homeowners will reduce electricity usage in response to this organized prompt (Kaufman, 2009).

The same kind of social-marketing tools can be applied to eco-driving. Many of the European programs include some form of competition in their eco-driving events, but obviously, we need this element to be included beyond just short-term events. For example, with the feedback gadget provided by Fiat, mentioned previously, drivers can gain access to what the company calls Eco:Ville. This consists of the community of feedback device users who choose to send their eco-driving results to a central site where individual results are ranked and compared. Participants gain the advantage of being part of a larger community of Fiat drivers, and also gain perspective on their own performance relative to others. Just as in the housing example, this can serve as a spur to achieve better fuel efficiency performance.

It has been shown that many Americans enjoy playing energy conservation "games" with their automobile feedback devices installed in hybrid-electric vehicles, engaging in a form of social competition as to who drives the furthest on battery power alone, and who gets the best fuel mileage over time. Many are eager to post their results on-line and engage others in discussion of comparable results. Organizing such discussions around popular social networking sites such as MySpace or Facebook is certainly possible as feedback devices become commonplace (Carnegie Mellon, 2009).

Obviously, we are simply at the beginning stages of having a social-marketing approach to eco-driving. But the elements of such an approach are well known and can serve to engage the American public in an eco-driving campaign. Opportunities will present themselves as we transition to a new automotive future based on entirely new models and the transition from oil to electric vehicles.

7. Conclusion

We have seen that the inclusion of eco-driving, within a suite of policies designed to trigger behavioral changes for the benefit of the planet, has the potential to reduce carbon emissions from cars significantly. Its primary advantages are that it can apply to any vehicle (old or new, big or small), take effect across the entire fleet of vehicles immediately (as opposed to being phased in), and result in a net savings to individuals from day one (from greater fuel efficiency and perhaps from lower insurance rates). Despite the cost savings, some will resist because it constitutes a deviation from standard operating procedures and requires a learning process.

Governments can put programs in place to overcome opposition and have some expectation of success. But if major savings are the goal, eco-driving will have to constitute a more prominent role in the overall US climate mitigation program than it does in the European cases. This can be accomplished through: (1) a major public awareness and information campaign, highlighting the cost savings to individuals and putting an attractive and compelling spin on eco-driving; (2) reducing and enforcing interstate speed limits; (3) making eco-driving training widely available and free to individuals (with the government cost-sharing the costs with the automobile industry); (4) cost-sharing the costs of purchasing and installing driver feedback devices (between the government and individuals); (5) enlisting the services of social-marketing experts for the essential norm-creation process.

While initial government responses to climate change will involve the traditional regulated community, the problems facing us from climate change are so severe that we cannot afford to neglect individual contributions to the problem; particularly when the collective contributions are so large. The promotion of eco-driving would be a relatively low-cost, high-payoff initiative that could be taken in concert with other transportation climate mitigation options. The evolution from gasoline-powered vehicles to electrical or hybrid vehicles provides a golden opportunity to emphasize eco-driving, since eco-driving is particularly critical to obtaining desired fuel savings in hybrids. A new driving style for a new automotive future makes eminent sense.

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