



BUILDING A NETWORK OF SOLUTIONS



Photo: Rowan Kilian

Ecodriving

The Science and Art of Smarter Driving

RONALD KILLIAN

The author is Manager of Environmental Permits and Procedures, Highway Division District 6, Massachusetts Department of Transportation, Boston.

(Photo above:) More than 30 states and the District of Columbia have some sort of anti-idling regulation. Drivers can avoid engine idling and employ fuel-saving driving techniques to reduce the GHG output of personal vehicles.

Ken leaves home for work. He warms up his car engine in the driveway. His car roof and trunk are loaded with unnecessary equipment; the tires are underinflated. Ken drives with jack-rabbit starts-and-stops to pick up his breakfast, idling his automobile in the fast-food drive-through lane. He then heads on to the toll road, driving at up to 70 mph with the car windows open until reaching the traffic jam at the toll booths; without a transponder, he cannot zip through the EZ-Pass lane.

Arriving at work, Ken parks in a space that requires backing out when he leaves, not driving forward. After work, he drives to the drugstore, but forgets about his other errands until arriving home; then he drives back out to the grocery store and the post office.

Ken is not a smart driver—and he is contributing to energy waste and climate change.

Driving Smarter

With the U.S. and global economies struggling, with the nation dependent on foreign oil, with gasoline prices edging toward \$4 per gallon, and with the effects of climate change becoming more apparent, many government agencies are searching for quick fixes and longer-term strategies to reduce fuel consumption and costs, vehicle- and roadway-related expenses, and carbon emissions. This is appropriate, because U.S. transportation consumes 28 percent of the nation's energy—approximately 13 million barrels of petroleum per day (1). In 2009, according to a report assessing U.S. transportation infrastructure, "Americans wasted 4.8 billion hours and 3.9 billion gallons of fuel sitting in traffic, at a cost of \$115 billion—more than one-sixth the amount of oil imported annually from the Persian Gulf" (2).

One simple, economical way that individuals, businesses, and governments can combat inefficient

vehicle fuel consumption and its adverse effects is by adopting smarter driving techniques through eco-driving—also known as green driving, smart driving, and fuel economy—maximizing behavior. Ecodriving is an approach that incorporates techniques and technologies to reduce fuel consumption and costs, greenhouse gas (GHG) and other air pollutant emissions, vehicle miles traveled (VMT), vehicle and road degradation, and accident-related costs—such as property damage, injuries, fatalities, and insurance.

Ecodriving techniques can improve fuel economy by up to 33 percent for some drivers—for example, the distance traveled by an ecodriver on \$4 of fuel would require \$5.32 of fuel for an aggressive driver. Technological innovation and route selection are part of the program, through intelligent transportation systems (ITS) and adaptive driving behavior. In sum, ecodriving combines the science and art of efficient and safe driving with the American spirit of individual and collective responsibility and action (3, 4).

Evolving Principles

Ecodriving evolved in the United States from the “hypermiling” adopted by hybrid vehicle driving clubs.¹ Hypermilers exceed a vehicle’s fuel efficiency as estimated by the U.S. Environmental Protection Agency (EPA), by modifying driving habits and adopting techniques originally applied in the Mobil Economy Run—an annual coast-to-coast road trip and demonstration that started in the late 1930s; and in the years of gasoline rationing during World War II; during the 1973 oil crisis; in the U.S. Department of Energy’s short-lived Driver Energy Conservation Awareness Training Program; and later in times marked by the worldwide volatility of fuel prices (5).

Ecodriving is recognized internationally for its health, safety, and environmental benefits and for its contributions to national security. Ecodriving is included in the 2007 report of the United Nations’ Intergovernmental Panel on Climate Change (6), in recommendations from the International Energy Agency (7), and in a report of the World Health Organization (8). Green Communities Canada has established an EcoDriver Program, and Canada’s ecoENERGY-vehicles program applies ecodriving principles. European examples include ECOWILL² and programs in the Netherlands,³ Switzerland, Germany, and Austria. Programs are in place in Japan, Australia, and other countries.

Ecodriving has yet to mature as a national energy and emissions reduction policy in the United States

¹ See www.CleanMPG.com.

² www.ecodrive.org; www.ecodrive.org/en/what_is_ecodriving/benefits_of_ecodriving/.

³ www.hetnieuwerijden.nl.

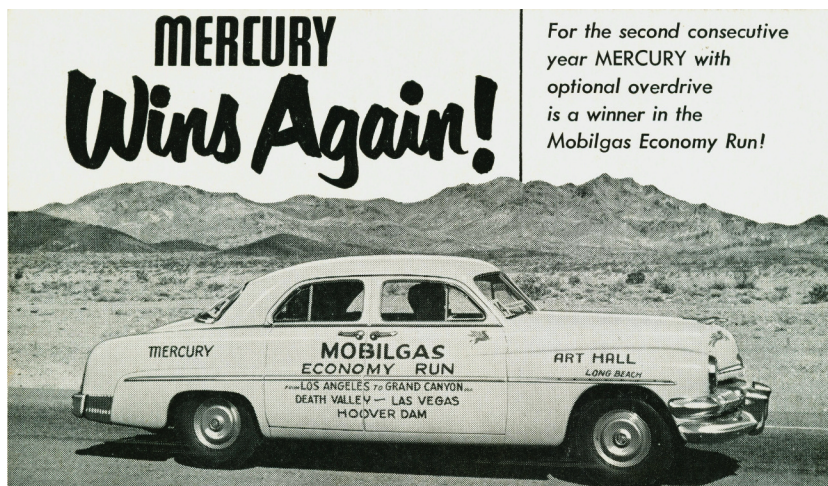


PHOTO: ADREN JEWELL

but is a key measure in the Global Warming Solutions acts in California and Massachusetts; in North Carolina Department of Transportation’s (DOT’s) “Drive Green, Save Green” campaign; in the New England Governors’ Conference resolution to create an ecodriving clearinghouse⁴; and in the campaign of the I-95 Corridor Coalition.⁵ In addition, the Driving School Association of the Americas passed a resolution in support of ecodriving in 2009.⁶

An integrated, robust, national ecodriving strategy is a logical next step to reap the economic, national security, environmental, and social benefits from this low-cost, high-value approach.

The Mobil Economy Run, an annual coast-to-coast competition for fuel-efficiency that ran from the 1930s to the 1960s, was an early showcase of ecodriving techniques.

Elements of Ecodriving

A review of several ecodriving programs and studies in Europe and North America reveals four main elements of a successful program:

1. Communication and marketing with public- and private-sector support;
2. Driver and instructor training;
3. Policy support with limited legislation and regulation; and
4. Research on behavioral factors and incentives, on quantifying and measuring benefits, and on vehicle technology and ITS.

Communications and Marketing

Educating drivers and fleet managers about how to become ecodrivers is an important element in any program, but societal understanding and acceptance are needed as well. Messages delivered through a variety of media to develop positive branding for ecodriving are necessary to capture the driving public’s attention.

⁴ Resolution No.194, 2010.

⁵ www.I95coalition.org.

⁶ www.thedsaa.org.

In its *Guide to Green Driving*, the Alberta Motor Association in Canada recommends regular tire pressure checks.



PHOTO: ALBERTA MOTOR ASSOCIATION

Although ecodriving is one of the most effective strategies for reducing fuel expenses and GHG emissions,⁷ an ecodriving campaign does not need to focus on cost savings and climate change, especially in areas in which skepticism about climate change remains high. At a 2011 workshop, Elliot Martin of the University of California, Berkeley, suggested that rebranding ecodriving as a national security measure might broaden its support (4).

The Internet provides basic and extensive sets of ecodriving tips—more than 100 pointers can be assembled from several websites—and most are ready to implement for immediate results. Top tips usually include the following:

⁷ Even with the modest assumption that only 20 percent of drivers would adopt the maximum scenario for ecodriving, Cambridge Systematics projected in the 2009 report *Moving Cooler* (www.movingcooler.info) that ecodriving would reduce GHGs cumulatively between 2010 and 2050 more than any other strategy, except strong pricing and a national 55-mph speed limit—more than aggressive strategies for land use, transit expansion, intercity rail, and employer-based trip reduction programs.

Massachusetts DOT's digital billboard messages are seen daily by thousands of highway drivers.



PHOTO: GERARD KELLER, MASSACHUSETTS DOT

◆ **Drive less and chain trips** to minimize time, fuel consumption, and VMT.

◆ **Go easy on the pedals.** Rapid starts and stops can increase fuel use by up to 40 percent. Maintain a constant speed and coast when possible.

◆ **Turn the engine off**—idling wastes fuel and money for zero mph. Idling for 10 seconds consumes more fuel than starting a vehicle. EPA lists more than 30 states and the District of Columbia with some form of anti-idling regulation (9), and campaigns against engine idling are under way in New York City, Minneapolis, Canada, Japan, and Europe (10). In the United States, an estimated 3.8 million gallons of gas and \$15 million (at \$4 per gallon) are wasted daily through voluntary idling, which also generates 40,000 tons of carbon dioxide emissions (11).

◆ **Check tire pressure monthly.** In 2005, an estimated 1.2 billion gallons of fuel were lost by driving on underinflated tires. Proper inflation can provide up to a 3 percent benefit per tankful of fuel, contribute to optimizing road-holding and braking distance, and reduce tire failure. The California Air Resources Board approved a regulation in 2010 requiring automobile service providers to check and inflate each vehicle's tires to the recommended pressure when performing any maintenance or repair work.

◆ **Tighten the gas cap.** Loose, damaged, or missing fuel tank caps allow 147 million gallons of fuel to evaporate annually.

◆ **Observe speed limits.** Fuel economy decreases 5 percent or more for every 5 mph above 60 mph in highway driving; for some vehicles, the decrease can start at 50 mph or less. Observing the posted speed limit—the standard for safe drivers—can increase fuel economy by 7 percent to 23 percent. Cruise control can improve highway mileage by 7 percent if used appropriately.

◆ **Watch your weight.** An extra 100 pounds in a vehicle can reduce the mileage per gallon by up to 2 percent. Roof racks and similar exterior accessories reduce fuel efficiency by increasing the aerodynamic drag.

◆ **Instant, fuel economy feedback displays,** like those installed in many hybrid vehicles for “dynamic ecodriving,” may reduce highway fuel use by 12 percent to 14 percent (4, 12).

◆ **Reduce air conditioning.** Because air conditioning can decrease mileage by 5 to 25 percent, use open windows at speeds up to 40 mph, and use air conditioning at speeds above 40 mph.

◆ **Buy a vehicle wisely.** A 2011 research report found that “vehicle selection has by far the most dominant effect” for on-road fuel economy—the best-performing vehicle sold in the United States is

nine times more fuel-efficient than the worst-performing vehicle. Nevertheless, the report warns not to neglect the effects of other driver-controlled factors—such as driving techniques, route selection, and vehicle maintenance—which can contribute to “a 45 percent reduction in the on-road fuel economy per driver” (13).

Creative Outreach

Varying the media can help in delivering the message. Websites with tips lists, videos, and virtual games involving driving skills are becoming more common.⁸ In 2011, Massachusetts DOT began displaying “Drive Smart and Save” public service announcements on seven new digital billboards along state highways. A state’s motor vehicles registry can disseminate ecodriving information to citizens through licensing, driver testing, and registration processes in paper and electronic formats.

Transportation agencies can be more creative in collaborating with the private sector, including organizations already involved in promoting safe and efficient driving—such as AAA, AARP, automobile manufacturers and dealers, and insurance companies and their foundations—as well as with the media, educational institutions, businesses, celebrities, and public officials. On-road, fuel-economy competitions can generate enthusiasm and interest, like the Green Grand Prix at Watkins Glen, New York.⁹

Driver and Instructor Training

In addition to general information for the public, a successful program includes the integration of ecodriving into the traditional training curricula for driving instructors and for new and licensed drivers. Experience in the Netherlands (14)—which began restructuring its programs in 1988—and in Austria and other European nations indicates the effectiveness of a two-phase approach (15):

1. One-on-one theoretical and practical training, followed by
2. Continued mandatory training and reinforcement after initial licensing.

⁸ Sample websites with ecodriving messages include Massachusetts DOT, www.mass.gov/MassDOT/DriveSmart; North Carolina DOT, www.ncdot.org/programs/drivegreen; Metropolitan Washington Council of Governments, www.mwcog.org/transportation/ecodriving/; U.S. EPA, www.fueleconomy.gov; and FuelClinic.com. The United Kingdom’s ecodriver.org has posted a video, www.youtube.com/watch?v=D8_iZNnsCro, and a Dutch video delivers tips via a parody of the *Dukes of Hazzard*, www.youtube.com/watch?v=Re92es9aPB8&feature=related.

⁹ www.greengrandprix.com.



In 2002 and 2003, more than 6,500 Dutch driving school teachers and examiners—that is, more than 90 percent—were trained in ecodriving principles; new driving manuals, driving exams, and refresher courses were introduced. Recent studies and workshops in Europe (7, 16), California (4), and Quebec (17) confirm the findings from earlier studies that without positive reinforcement, drivers’ incentives and motivation to maintain a high level of compliance with ecodriving principles may wane within several weeks to months after the initial training. The initial improvements in fuel economy of 5 to 15 percent or more can drop to 5 percent without continued support (18).

Governmental Support

Governmental support for ecodriving programs and research is crucial. The motivations may vary but should resonate with the public—economics, public health and safety, national security, or even mitigating climate change. Vehicle fuel-economy standards are a key policy measure (19). The adoption and enforcement of anti-idling regulations are warranted for public health, cost savings, and fuel economy.

At least 33 countries have adopted electronic speed-limiter legislation, primarily for trucks and buses; these include the nations of the European Union, as well as Australia, India, Japan, and the

Creative media can help deliver the ecodriving message—such as this Dutch parody of the *Dukes of Hazzard* on YouTube.



A Factory Five diesel developed by West Philadelphia High School students leads the race at the Green Grand Prix in Watkins Glen, New York. The first stage of the competition takes place on the Watkins Glen International grand prix circuit; the second stage is conducted on local roads.

Feedback mechanisms such as the one installed in the Toyota Prius allow drivers to monitor and adjust their driving for maximum fuel efficiency.

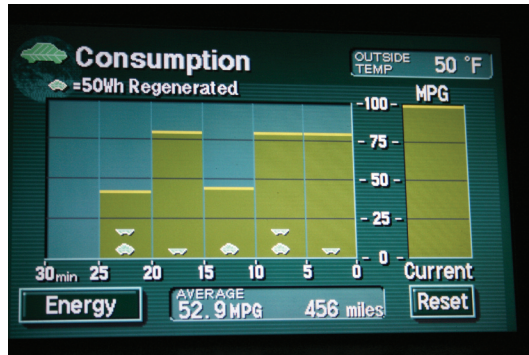


PHOTO: RONALD KILIAN

Canadian provinces of Ontario and Quebec¹⁰ (20). In response to petitions from the American Trucking Associations, Road Safe America, and several motor carriers, the National Highway Traffic Safety Administration is expected to propose a rulemaking for a 68-mph truck limiter in summer 2012 (21). Nonetheless, ecodriving will advance more through education and cooperation than through government fiat—but legislation and regulations can play an essential supporting role.

Topics for Research

Longer-term and larger-scale research on the science and art of ecodriving remains critical to developing the best training programs; marketing and public education campaigns; real-time feedback mechanisms—such as the ScanGauge monitor or those installed in the Toyota Prius; and ITS and other vehicle-related technologies. Research also can improve understanding of driver behavior, motivations, and incentives and can enable more precise measurement of the many benefits of ecodriving.

Significant ecodriving research programs are under way at the University of California's Multi-Campus Research Program at Berkeley, Riverside, and Davis; and at the University of Michigan's Transportation Research Institute, Texas A&M Transportation Institute, and various U.S. DOT-sponsored and European programs.

Fleet Managers Lead the Way

Fleet managers are aggressively advancing ecodriving, primarily because of its cost savings. Managers of business, government, and military fleets are developing programs that decrease fuel consumption and increase safety and savings. Many have benefited from the EPA's SmartWay Program, a public-private collaboration with the freight transport industry.¹¹ Since its inception in 2004, Smart-

¹⁰ Australia adopted a 62-mph limiter setting in 1990; the European Union followed suit in 1994; Japan chose a setting of 56 mph in 2003, and Ontario and Quebec went with 65 mph in 2009.

Way has assisted more than 2,900 U.S. corporations, including many of the nation's largest truck carriers, with supply-chain accounting tools and methods and has helped them save 50 million barrels of oil and \$6.1 billion in fuel, while cutting more than 16 million metric tons of carbon emissions.

SmartWay emphasizes fuel-efficient technologies and ecodriving techniques, including reduced idling and speeds, improved aerodynamics and weight reduction, automatic tire inflation systems, single wide-based tires, driver training, and freight logistics. The program is producing results. At the November 2011 U.S. Freight Sustainability Summit, for example, SmartWay member Con-way reported that since 2008, it has achieved an annual reduction of approximately 6 million gallons of diesel fuel and 134 million pounds of carbon emissions from its fleets of 8,400 tractor trailers and 2,700 long-haul trucks by turning back the speed governors from 65 to 62 mph for tractor trailers, and from 70 to 65 mph for long-haul trucks.

Private-sector successes are many. United Parcel Service has minimized left-hand turns on delivery routes since 2004, saving 10 million gallons of fuel and reducing carbon dioxide emissions by 100,000 metric tons, equal to 5,300 passenger cars off the road for one year. Staples, Inc., has developed the EcoEasy program, which limits the top speed of its 1,750 delivery trucks, uses anti-idling technology and shift-point speed changes, purchases electric delivery vehicles, and provides special driver training. Fuel economy has improved by more than 25 percent since 2007, and the company has saved nearly 1 million gallons of diesel fuel annually.

Frito-Lay has applied an intensive approach to achieve more efficient driving by its 19,000 drivers for a fleet of 17,000 trucks. Three programs—Smart Miles, Smart Driver, and Road to Green—focus on vehicle technology and maintenance, driver training and follow-up support, and route management to reduce fuel consumption and maintenance costs, VMT, accident rates, and carbon dioxide emissions. Since joining SmartWay in 2005, Frito-Lay has saved more than 15 million gallons of fuel.

Changing Habits

Ken leaves home for work, warming up his car engine by driving his car immediately after turning on the ignition. His car is freed of its roof rack and of junk in the trunk, and the tires are properly inflated. He drives smoothly and carefully on his way to pick up breakfast. He parks the car, turns off the motor, and walks into the restaur-

¹¹ www.epa.smartway.

rant. Afterward, Ken heads on to the toll road, driving as smoothly as possible through heavy traffic at 55 to 60 mph, with the windows closed. He anticipates slowdowns and avoids the traffic jam near the toll booth by zipping through the EZ-Pass lane with his transponder. He arrives at work and parks in a space that allows him to pull out going forward. Leaving work, he has planned out the shortest route home while running his errands at the drug store, grocery store, and post office. Ken is developing into an ecodriver.

Transportation and environmental agencies and regional organizations are positioned to take the lead in promoting ecodriving as an inexpensive, cost-effective, energy-efficient method that saves money; reduces fuel consumption, carbon emissions, VMT, and the costs of property damage, medical care, and insurance; and supports national security by reducing dependence on foreign oil. More effective marketing of this simple technique for saving money, energy, and reducing emissions should be pursued.

Additional research will increase understanding of more effective approaches to educating the public about ecodriving techniques and about the role of vehicle technology and ITS. More accurate metrics are needed for measuring the benefits of ecodriving, which should become a staple of daily driving habits in the United States.

References

1. *National Transportation Statistics 2011*. Bureau of Transportation Statistics, Research and Innovative Technology Administration, U.S. Department of Transportation, 2012. www.bts.gov/publications/national_transportation_statistics/.
2. *Building America's Future: Falling Apart and Falling Behind—Transportation Infrastructure Report 2011*. Building America's Future Education Fund, Washington, D.C., 2011. www.bafuture.org/sites/default/files/Report_0.pdf.
3. Energy and Economic Analysis, Inc. *Owner-Related Fuel Economy Improvements*. Oak Ridge National Laboratory, Oak Ridge, Tennessee, December 2001. www.fuel-economy.gov/feg/pdfs/OwnerRelatedFuelEconomyImprovements.pdf.
4. Shaheen, S., M. Barth, and N. Chan. *Final Report of the Proceedings of the UC MRPI Ecodriving Workshop, May 18, 2011*. Institute of Transportation Studies, University of California, Berkeley, November 2011. www.ecodrivingworkshop.cert.ucr.edu/.
5. *Fuel Economy-Maximizing Behaviors*. Wikipedia. http://en.wikipedia.org/wiki/Fuel_economy-maximizing_behaviors.
6. Ribeiro, S. K., S. Kobayashi, M. Beuthe, J. Gasca, D. Greene, Y. Muromachi, P. J. Newton, S. Plotkin, D. Sperling, R. Wit, and P. J. Zhou. *Transport and Its Infrastructure*. In *Climate Change 2007*. Intergovernmental Panel on Climate Change. www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter5.pdf.
7. Kojima, K., and L. Ryan. *Transportation Energy Efficiency: Implementation of IEA Recommendations Since 2009 and Next*



PHOTO: COUNTY/LEMONADE, FLICKR

- Steps. International Energy Agency, Paris, September 2010. www.iea.org/papers/2010/transport_energy_efficiency.pdf.
8. *Health in the Green Economy: Health Co-Benefits of Climate Change Mitigation—Transport Sector*. World Health Organization, Geneva, Switzerland, December 2011. www.who.int/hia/green_economy/en/index.html.
9. *Compilation of State, County, and Local Anti-Idling Regulations*. U.S. Environmental Protection Agency, April 2006. www.epa.gov/region8/air/rmcdc/pdf/CompilationofStateIdlingRegulations.pdf.
10. Burgess, E., M. Peffers, and I. Silverman. *Idling Gets You Nowhere: The Health, Environmental, and Economic Impacts of Engine Idling in New York City*. Environmental Defense Fund, Washington, D.C., February 2009. www.edf.org/sites/default/files/9236_Idling_Nowhere_2009.pdf.
11. *Anti-Idling Primer—Every Minute Counts*. Hinkle Charitable Foundation. www.thehcf.org/antiidlingprimer.html.
12. Shaheen, S. A., E. W. Martin, and R. S. Finson. *Ecodriving and Carbon Footprinting: Understanding How Public Education Can Reduce Greenhouse Gas Emissions and Fuel Use*. Mineta Transportation Institute, San José State University, San José, California, April 2012. <http://transweb.sjsu.edu/project/2808.html>.
13. Sivak, M., and B. Schoettle. *Eco-Driving: Strategic, Tactical, and Operational Decisions of the Driver That Improve Vehicle Fuel Economy*. University of Michigan Transportation Research Institute, Ann Arbor, August 2011. <http://deep-blue.lib.umich.edu/bitstream/2027.42/86074/1/102758.pdf>.
14. Wilbers, P., and H. Wardenaar. *The Dutch National Ecodriving Programme Het Nieuwe Rijden: A Success Story*. In *ECEEE 2007 Summer Study, Saving Energy—Just Do It!* ECEEE Secretariat, Stockholm, Sweden, June 2007, pp. 1673–1678.
15. *Overview on the Status of Ecodriving Integration in the Driver Education and Testing*. Ecodrive.org and Intelligent Energy Europe, November 2011.
16. *Workshop on Ecodriving—Findings and Messages for Policy Makers*. International Transport Forum, Paris, November 2007.
17. *Eco-Driving Training Pilot Project for Light Vehicles: Summary Findings*. Quebec Bureau of Efficiency and Energy Innovation, Canada, November 2011.
18. *To the Point 3—Studies on “Drive Like a Pro”—Safe Driving, Both in a Professional and a Private Context*. German Road Safety Council, Bonn, 2009.
19. *Eco-Driving Index*. University of Michigan Transportation Research Institute, Ann Arbor, June 2012. http://www.umich.edu/~umtrswt/EDI_sales-weighted-mpg.html.
20. *Learning from Others: An International Study on Heavy Truck Speed Limiters*. Transport Canada, Ottawa, Ontario, 2009.
21. *Federal Register*, Vol. 76, No. 1, Jan. 3, 2011, pp. 78–80.

Southern Parkway in Utah posts a speed limit of 60 mph. Cars tend to be more fuel-efficient at 60 mph than at 65 mph; observing posted speed limits also can increase fuel efficiency.