Residential Transportation Energy Assessment Pilot Program

STEPHANIE MORSE
KAREN GLITMAN
DAVID ROBERTS

January 2014

Vermont Energy Investment Corporation

veic.org

Tel: (802) 658-6060
Toll-free: (800) 639-6069

VEIC Headquarters:
128 Lakeside Avenue, Suite 401
Burlington, VT USA 05401

Acknowledgements

Generous support for this pilot project was provided by The High Meadows Fund (www.highmeadowsfund.org).

Background

The Vermont Agency of Natural Resources annual greenhouse gas inventory for 2011 shows that the transportation sector continues to constitute the largest source of greenhouse gas (GHG) emissions in Vermont (46%).[1] The vast majority of transportation energy comes from petroleum products used to fuel internal combustion engines. Taking action to reduce petroleum consumption will increase our economic and environmental well-being through decreased household and business expenses, reduced greenhouse gas emissions, reduced air pollutants and enhanced energy security.

The State of Vermont has developed a Comprehensive Energy Plan (CEP)[2] which calls for decreasing transportation energy use and shifting to renewable sources of energy to meet 90% of the state's energy needs by 2050. The CEP provides detailed recommendations to implement the plan and move Vermont closer toward the ambitious 2050 target. Increased efficiency will significantly reduce transportation energy consumption and facilitate a shift to renewable sources. Transportation efficiency can be accomplished in three ways: improvements in the efficiency of what we drive (e.g. electric vehicles); improvements in why we drive (e.g. location efficiency); and improvement in how we drive (e.g. eco-driving).

This pilot project focused on how we drive. With funding from the High Meadows Fund, VEIC piloted a program modeled after the Efficiency Vermont Smart Meter program. The Efficiency Vermont program enables homeowners to monitor their personal electric use with a plug-in electric meter that is loaned to them. This meter loan program has enabled thousands of Vermonters to assess their home electric energy use. This pilot project aimed to create a similar meter loan system for gasoline fueled vehicles. Measurements of vehicle fuel use were enabled through in-vehicle, on-board diagnostic (OBD) devices providing information on vehicle operations and fuel use. This study was designed to provide a number of travelers with an initial assessment of their transportation energy use, coaching on how they can reduce their fuel consumption, and subsequent follow-up monitoring to quantify the energy-use reductions attributable to the coaching.

Many resources discuss the benefits of eco-driving, or energy efficient driving practices, claiming that even minor changes in driving behavior can increase fuel economy and save drivers significant money.[3,4,5] While a few studies have

[1] http://www.anr.state.vt.us/anr/climatechange/Vermont_Emissions.html
[2] http://publicservice.vermont.gov/publications/energy_plan
[3] https://www.dot.ny.gov/ecodriving
[4] http://www.ecodrive.org/
[5] http://www.erating.org/transportation-company-education/courses

attempted to measure the real-world value of eco-driving,[6,7] more research is needed to understand and quantify eco-driving practices for personal vehicle transport.

Objectives

This pilot project aimed to test the potential gains in fuel economy achieved through efficient driving behavior. Specifically, 11 participants were selected to participate in the project in which:

- An initial fuel consumption assessment was performed to establish a baseline fuel economy for each participant;
- Customized coaching was provided based on data collected in the initial assessment to improve the efficiency of driving behavior; and
- A subsequent data collection period was used to quantify changes in fuel economy.

Methods

Data Collection Devices

Measurement of vehicle fuel use was enabled through in-vehicle, on-board diagnostic (OBD) devices referred to as OBD-ii, compatible with all motor vehicles manufactured after 1996. There are currently many OBD-ii devices available as well as software companies providing OBD data analysis. Researchers at the University of Vermont Transportation Research Center performed a review of available devices, software services, and data analysis techniques to ensure that the necessary data and accuracy were obtained.

Calculating fuel economy requires speed and fuel-use data. Nearly all OBD loggers record speed at regular intervals (usually 1 second or faster), but fuel-use data was not a parameter reported by any of the commercial OBD-ii devices reviewed. The EASE Mini-DL reports the fuel tank level as a percent of its capacity, but it was expected that resolution would not be enough to distinguish fuel economy at the trip level. Fuel use can be estimated, however, based on the engine's air intake (mass air flow) and the stoichiometrically ideal combustion-ratio for air and gasoline. While this approach does not account for periods when the engine is running either rich or lean, the engine control unit adjusts the

[6] Solomon, Laura, Nick Lange, Michael Schwob, and Peter Callas. *Effects of miles per gallon feedback on fuel efficiency in gas-powered cars.* UVM Transportation Research Center, 2009. Accessed from: http://www.uvm.edu/~transctr/research/trc_reports/UVM-TRC-10-004.pdf

[7] Stillwater, Tai. *Comprehending consumption: The behavioral basis and implementation of driver feedback for reducing vehicle energy use.* UC Davis Institute of Transportation Studies, November 2011. Accessed from: http://www.its.ucdavis.edu/research/publications/publication-detail/?pub_id=1518

air-to-fuel ratio on a second-by-second basis to keep it close to ideal for most of the vehicle's operating period. This fuel economy calculation approach is used by multiple OBD software companies reviewed, including EASE Diagnostics, GLM Software, Windmill Software, and FleetCarma.

After discussions with various companies, it was concluded that FleetCarma would provide the devices at the best price with the necessary accuracy. Rather than obtaining raw data from the FleetCarma devices and performing the fuel economy calculation ourselves, FleetCarma provided analyzed data through a user-friendly web portal.[8] Three devices were leased for three months for $900. FleetCarma generously allowed unlimited uses of the devices, meaning we could create as many participant entry logs as we could complete within the given time.

Participant Selection

With the effort to compile a diverse selection of participants for the pilot study, a recruitment email (see Appendix 1) was sent to various email listservs, including the Go Chittenden County individual and business lists, GreenUVM, the University of Vermont Rubenstein graduate list, Howard Center employees, the Vermont Association of Business Industry and Rehabilitation list, and the CATMA E-news. The email directed those interested to an online screening form (see Appendix 2) where they received more information about the pilot project and were able to sign up. The recruitment email and the screening form were used to limit participants to those who identified themselves as the primary driver of their vehicle and who lived or worked in Chittenden County (to minimize time needed to meet with participants). Respondents were also asked to include any scheduled vacations or anticipated disruptions in their typical driving patterns so these time periods could be avoided when planning the study.

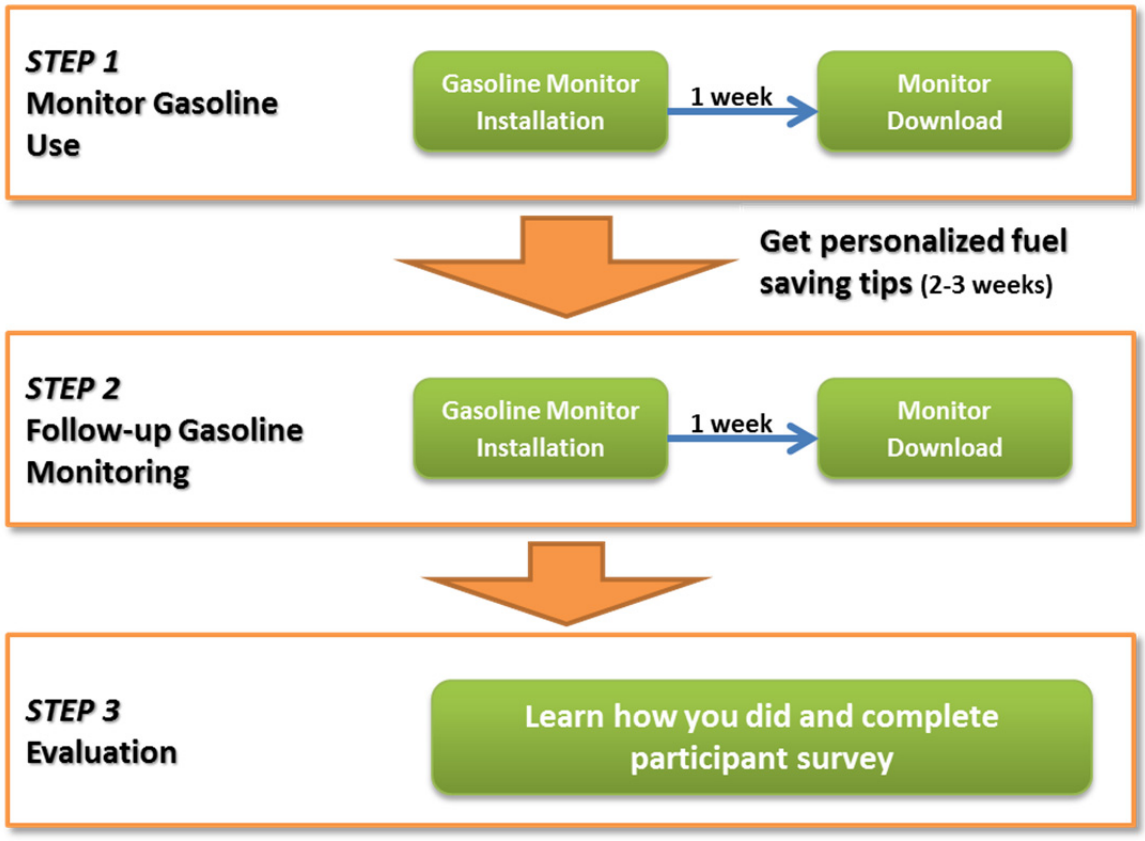
Thirteen people filled out the form and 11 responded to follow up communication and agreed to participate. Participants included three sustainability focused professionals, a retired professor, a university staff person who commutes via bicycle but drives for weekend activities, a young mother with two part time jobs, a mother who shares her vehicle with her teenage son, two college students (one undergraduate and one PhD candidate), a small business owner who makes deliveries throughout the state, and one woman who is the predominant driver of her vehicle but shares it with her husband. Three men and nine women participated.

[8] http://www.fleetcarma.com/

Study Structure

Figure 1 below illustrated the basic project plan and structure to participants. The study was structured to collect data from the participants in two periods: the first period provided an initial fuel consumption assessment and the second period served as a follow up assessment after customized eco-driving coaching. The study structure was limited by the number of devices, the time period they were available and the number of participants. Due to these constraints, it was determined that each data collection period would need to be limited to one week.

Figure 1: Project Structure



Data collection and coaching occurred through four meetings with each participant as described in Table 1. Meetings 1 and 2 accomplished the first data collection period and meetings 3 and 4 the follow-up monitoring. After the fourth meeting, participants learned about their results and were asked to complete an evaluation survey via email.

Table 1: Participant Meeting Plan

Meeting	Tasks
Meeting 1	Consent form signed by participant Data collection device installed in participant's vehicle
Meeting 2	Data collection device removed
	Data uploaded, analyzed, and compiled for coaching
Meeting 3	Coaching: data and eco-driving materials (tailored based on participant's initial driving assessment) discussed Data collection device reinstalled
Meeting 4	Data collection device removed

Data collection periods were staggered to maximize the number of participants that could be scheduled in the three month period while being mindful of participants' schedules and attempting to avoid periods of atypical driving (e.g. participant on vacation and not commuting for the week). Because some time was needed between meetings 2 and 3 to analyze and compile each participant's data, devices were installed in the next participants' vehicles during this time. The final schedule is shown in Figure 2, illustrating the staggered approach.

Figure 2: Study Schedule

week of:	8/19	8/26	9/2	9/9	9/16	9/23	9/30	10/7	10/14	10/21	10/28	11/4	11/11
P1			Mtg. 1 W. 9/4	Mtg. 2 F. 9/13		Mtg. 3 W. 9/25	Mtg. 4 F. 10/4						
P2			Mtg. 1 F. 9/6	Mtg. 2 F. 9/13				Mtg. 3 S. 10/6	Mtg. 4 S. 10/13				
P3			Mtg. 1 W. 9/4	Mtg. 2 Th. 9/12	Mtg. 3 W. 9/18		Mtg. 4 M. 9/30						
P4	Mtg. 1 F. 8/23		Mtg. 2 T. 9/3		Mtg. 3 T. 9/17	Mtg. 4 W. 9/25							
P5							Mtg. 1 M. 9/30	Mtg. 2 W. 10/9		Mtg. 3 T. 10/22	Mtg. 4 Th. 10/31		
P6	Mtg. 1 F. 8/23		Mtg. 2 T. 9/3		Mtg. 3 M. 9/16	Mtg. 4 T. 9/24							
P7	Mtg. 1 F. 8/23	Mtg. 2 F. 8/30				Mtg. 3 W. 9/25	Mtg. 4 W. 10/2						
P8							Mtg. 1 Th. 10/3		Mtg. 2 M. 10/14		Mtg. 3 M. 10/28	Mtg. 4 M. 11/4	
P9								Mtg. 1 W. 10/9		Mtg. 2 M. 10/21		Mtg. 3 M. 11/4	Mtg. 4 W. 11/13
P10									Mtg. 1 T. 10/15	Mtg. 2 W. 10/23		Mtg. 3 W. 11/6	Mtg. 4 W. 11/13
P11									Mtg. 1 T. 10/15	Mtg. 2 T. 10/22	Mtg. 3 F. 11/1		Mtg. 4 T. 11/12
	Device #1	Device #2	Device #3										

Data Analysis

As noted above, data analysis was largely unnecessary due to the service provided by FleetCarma. However, each participant's results were compiled to highlight the behaviors that could potentially be influenced through eco-driving (idling time, hard acceleration events, hard braking events, and total vehicle miles traveled), the overall fuel economy was noted, and the EPA estimated combined fuel economy for each participant's vehicle[9] was included for reference. A log of all trips made during the study period was also provided to participants with these behavioral statistics included for each trip.

Coaching

At the second meeting, participants were given a print out of an eco-driving presentation (see Appendix 3). This was compiled from previous presentations used by VEIC staff as well as from materials from the Certification for Sustainable Transportation Eco-Driving 101 training program.[10] It is important to note that the Certificate for Sustainable Transportation has developed a full training program; this was not used, but rather, materials were drawn from this program. Participants were asked to review these materials and consider implementing the vehicle maintenance tips if they were able before the third meeting at which point the data logging device was reinstalled.

During the third meeting, lasting approximately 30 minutes, participants were presented with their data compiled from the FleetCarma web portal. This together with the eco-driving presentation was shared with specific focus on the aspects where their data indicated room for improvement. For example, if a participant had a high percentage of hard accelerations, time was spent focusing in on the portion of the presentation covering smart starts and stops.

At the end of this coaching meeting, the data logging devices were reinstalled to start the second period of data collection.

[9] http://www.fueleconomy.gov/
[10] http://www.erating.org/transportation-company-education/courses

Results

After the four meetings, data from both study periods were compiled. The same characteristics that were highlighted during the coaching meeting from the first study period were compared with the second period and percent changes were calculated. Results were sent to each participant in an email including three items: 1) the table included as Appendix 4 showing his/her results summarized with all other participants' results; 2) the data log of all trips in his/her two study periods (an example log is included as Appendix 5); and 3) an email providing a rough interpretation of his/her results. The bodies of the emails sent are included in Appendix 6.[11] In this email, participants were also asked to complete a survey on their experiences in the pilot project.

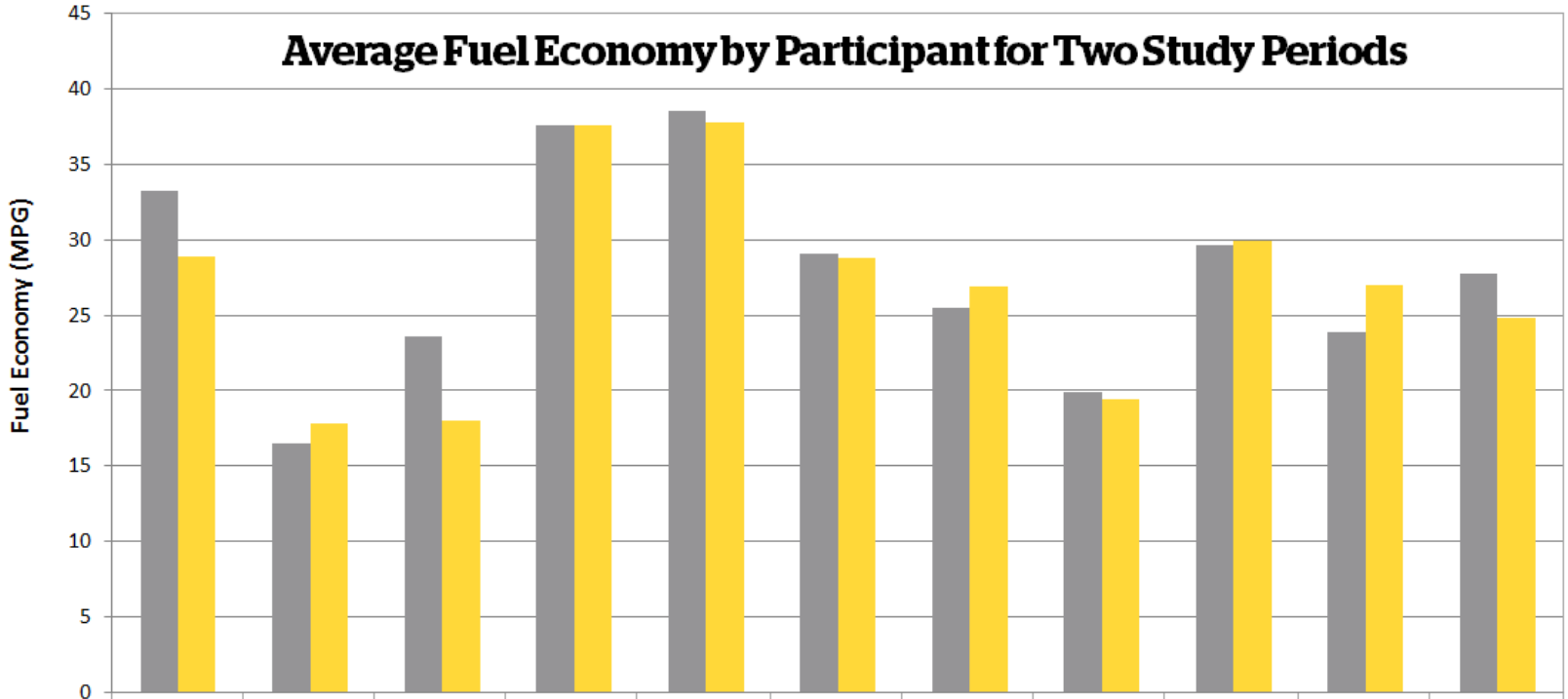
As seen in Appendix 4, overall, an improvement in fuel economy did not occur, and in fact, a slight loss (-2.3 percent) was observed. Figure 3 below illustrates the change in fuel economy between the two study periods for each participant. Four participants improved their fuel economy, one participant showed no change, and six participants had reductions in their fuel economy. A maximum increase of 12.8 percent was accomplished by Participant 10, but Participant 3 experienced a much larger decrease in fuel economy of 23.6 percent.

Overall, changes in behavior corresponded with fuel economy changes in the expected direction (see Appendix 4). For example, participants who reduced their hard starts, stops, and idling time also showed improved fuel efficiency. However, one participant improved on all behaviors monitored but had a decrease in fuel efficiency. Subsequent conversations with this participant indicated that this was likely the result of an exhaust pipe issue that was starting to break apart over the course of the study.

While efforts were taken during the screening and scheduling process to avoid data collection during times of atypical driving, multiple participants had significantly different driving patterns between the two periods, which potentially impacted their results. For example, Participant 3 drove a total of nearly 486 miles in the first period and only 77 in the second, with a significant reduction in average speed as well. This indicated (and the trip logs confirmed) that the first period included longer, highway type trips while the second period included many more short, in-town trips. The resulting change in fuel economy seems more likely attributable to this shift rather than to changes in driving behavior.

[11] Over the course of the four meetings with each participant, a level of familiarity was developed. This is stated as an explanation for the casual tone and potentially unclear references in the unedited email communications included here.

Figure 3: Fuel Economy Results



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
period 1	33.23	16.48	23.58	37.60	38.50	29.12	25.53	19.92	29.65	23.90	27.72
period 2	28.93	17.86	18.02	37.61	37.78	28.79	26.88	19.42	29.94	26.95	24.81
% change	-12.9%	8.4%	-23.6%	0.0%	-1.9%	-1.1%	5.3%	-2.5%	1.0%	12.8%	-10.5%

Survey Responses

Six participants responded to the survey provided at the end of the study (see Appendix 7). Interestingly, these responses represent Participants 1, 3, 5, 6, 9, and 11, all but one of whom showed decreases in fuel economy (see Figure 3), yet they all reported a positive experience with the study. Participants were split with 50 percent indicating that they saw a "slight benefit" and 50 percent a "significant benefit". Comments to this question showed that the benefit was largely reinforcing and making them more aware of their driving behavior. Multiple questions were asked addressing which of the eco-driving tips and behaviors participants practiced before the study and which of those they would implement as a result of the study. Nearly all participants frequently or always practiced nearly all of the tips and indicated that they would continue doing so. The final two questions asked about ways to improve the study and if participants had anything additional to add. One participant indicated that when looking at the driving log, it was difficult to think back and remember her driving habits. Another participant suggested ways in which eco-driving workshops could be used to educate "typical drivers". Another driver indicated that longer study periods could be helpful, and that a self-selected group is not likely to include those who "really need the coaching".

Discussion

While potential issues can be identified with this pilot project, at very least, it showed that the efficiency gains from eco-driving training with individual drivers (suggested to be as high as 25-30 percent) are not easily achieved. Shortcomings and potential causes for the lack of fuel economy improvements in this study are discussed below along with suggestions for future research, but ultimately, the cost effectiveness of any such eco-driving endeavors must be considered. Further research and refined methods may improve the results, but to what extent and at what cost? This balance must be evaluated.

First, there is the potential that further analysis into the data from this project could reveal more subtle gains in efficiency. With such short study periods, some participants had significantly different travel patterns between the two periods. It may be informative to attempt to control for the impact of this and compare like trips (e.g. identify and compare in-town trips). However, time did not allow for this level of analysis in this study.

Another very likely explanation of the lack of overall fuel economy gains is that a biased sample was obtained due to the self-selecting nature through which participants were recruited. While it is believed that we reached a diverse group of potential participants, it appears that those who responded to the recruitment email were already engaged in considering efficiency. On average, participants' fuel economy was higher than the EPA combined estimates for their vehicles in the first study period, indicating these participants were already very efficient

drivers. After conversations with the participants, it became even clearer that they were very interested in and aware of fuel efficiency and already practiced many eco-driving behaviors. For example, considering the percent of total acceleration or braking events as hard, representatives from FleetCarma indicated that they would expect an "aggressive" driver to have 30 percent or more as hard, a "normal" driver to have between 15-20 percent hard, and an "eco" driver to have less than 10 percent hard. Of all participants over both study periods, the highest rate observed was one participant with 16 percent hard stops, and most participants were well under 10 percent for both hard acceleration and braking. With such efficient baselines, it was difficult to find substantial areas for improvement.

Another potential explanation of the results in this study could be a lack of understanding of how to change behavior due to the lack of immediate feedback, or real-time displays of fuel efficiency. While gains vary, previous studies[12,13] in which improvements in fuel economy were realized often (if not always) included real-time, immediate feedback. Driving logs in this study helped participants identify which trips were more efficient than others, but the lack of immediate feedback connecting this to their behavior presented a challenge. For example, one participant was noted saying, "Wow, that was a bad trip. I wonder what I did." We could talk conceptually about good, efficient behaviors versus bad, inefficient behaviors, but without connecting it directly to what was occurring in the vehicle likely diminished the potential impact.

It is also possible that changing driving behavior requires a far greater effort and external pressure than the economic savings presented.

Efficiency vs. Conservation

Efficiency is typically thought of as "using less energy to provide the same service."[14] This definition is used to differentiate efficiency from conservation, or consuming less of a service. In this light, efficiency does not require sacrifice. Conservation, on the other hand, requires an acceptance of reduced service. For example, utilizing a new technology that enables a room to be heated to the same temperature using less energy is an efficiency measure; turning down the temperature a few degrees is a conservation measure.

Eco-driving is often considered a strategy for improving fuel efficiency. However, what is the service being provided? If it is simply vehicle miles traveled, than eco-driving can in fact be considered an efficiency measure; the same vehicle miles can be traveled using less gasoline. Drivers are not expected to give anything up or reduce their level of driving.

If we consider the service provided to be a level of driving in a given amount of time, than eco-driving could be considered a conservation measure. To achieve fuel economy gains through eco-driving, drivers must change their behaviors

[12] Solomon et at. 2009
[13] Stillwater 2011
[14] http://eetd.lbl.gov/ee/

and expectations. They need to slow down and their satisfaction with their driving experience may be reduced in that it may take longer to accomplish the same level of driving or they may not feel the same control and excitement many drivers associate with more aggressive driving behavior.

This is not simply a question of semantics. Considering eco-driving a conservation practice rather than an efficiency practice requires a shift in approach. If we think of eco-driving as an efficiency measure, we risk promoting the perception that all that is needed is a few behavioral shifts and suddenly, fuel economy is improved. Instead it appears likely many drivers must be willing to accept the behavior changes necessary to forego fast driving and other inefficient transportation practices.

Future Research and Recommendations

It is interesting that participants with little to no improvement in fuel economy reported finding the study beneficial. While reinforcing good driving behavior is a positive outcome, improving fuel economy must be the end goal. Further, to be cost effective, the gains in fuel efficiency should have greater value than the cost of the program. Several potential avenues for related future research are suggested below.

Cost-Benefit Screening

Using more robust recruiting or sampling methods and devices with real-time feedback both hold potential for improved results. However, assessing the costs and benefits of future, more costly eco-driving programs is a critical next step.

The Public Service Department of Vermont has a state screening tool, created in 2000, used to assess the net present value of proposed efficiency projects. By calculating energy saved (traditionally, kWh) and factoring avoided externalities (e.g. GHG emissions), the tool produces estimates of net societal benefits. This screening tool could be used to determine the efficiency gains that would be necessary to justify proposed budgets of various eco-driving endeavors.

Supporting Long Term Efficient Behaviors

Some drivers may feel sustained eco-driving practices require sacrifices they are not prepared or able to make. Even in these cases it is possible to achieve significant decreases in energy consumption, greenhouse gas emissions and fuel expenses through long term behaviors, such as more efficient vehicle purchases (including hybrid and electric vehicles). Changes to travel patterns to reduce trip lengths, such as home purchases in closer proximity to work or shopping locations present additional opportunities. These changes were beyond the scope of this pilot study, but resources are available for Vermonters

when they make vehicle purchase decisions[15] and/or consider where to live or work.[16] These resources could be refined and targeted to increase their effectiveness and support transitions which reduce fossil fuel use.

Fleet Focused Programs

This pilot project focused on individual drivers and many of the issues encountered seemed to be a function of this. It was time intensive and costly, and the potential economic savings alone did not appear to provide the necessary incentive to significantly change the participants' behavior. However, a workplace or fleet centered program may prove more effective. Employees could be encouraged to participate (helping to alleviate the self-selection bias), devices could be exchanged at work (reducing the time and cost necessary), and coaching could be conducted with a group (further reducing time and costs necessary). In a fleet setting, managers could impose additional external factors (e.g. penalties) or controls (e.g. vehicle speed restrictors). Additionally, if some sort of contest could be established, the motivation to win could function as the necessary encouragement for the behavioral changes needed for conservation.

Fleets present more opportunities to support efficient vehicle purchase decisions as they are regularly upgrading and increasing their operations. Fleet owners should also consider vehicle total cost of ownership (TCO) when evaluating purchasing options. As an example of this, FleetCarma has tools available for fleet managers to compare the estimated TCO of different vehicles based on actual logged data.

Conclusion

This pilot report is not intended to imply eco-driving programs are not worthwhile, but serious consideration should be paid to the costs and benefits of such efforts. Low cost eco-driving methods exist and are in practice,[17] and should be used if there are cost effective means to deliver, measure and verify the results of these programs.

The individual nature of this driver behavior research was time consuming and the limited budget available for the pilot was a challenge. The data logging OBD monitors required significant time for planning and coordinating the effort. Dropping off and picking up the devices twice, for 11 participants alone took approximately 50 hours, even with efforts to limit participants to the nearby surrounding areas.

Overcoming the implications of a self-selected sample is also critical. This presents perhaps the greatest challenge. Participants with fuel economies already well over EPA estimates for their vehicles are not likely to improve their

[15] e.g. http://www.driveelectricvt.com/
[16] e.g. http://www.locationaffordability.info/
[17] e.g. http://www.erating.org/transportation-company-education/courses

fuel economy significantly, if at all. Therefore, it must be determined how to attract participants that are not already interested in and considering fuel efficiency.

At this point we do not recommend pursuing widespread implementation of a vehicle meter loan program for individual drivers, although additional research may be warranted. Many vehicles currently for sale have built-in systems to monitor energy consumption and provide real-time feedback to drivers which could be harnessed to improve driver efficiency. This may present a good long-term solution to increasing motor vehicle efficiency through eco-driving awareness.

Appendix 1: Participant Recruitment Email

Interested in saving money on gas? Volunteers needed!

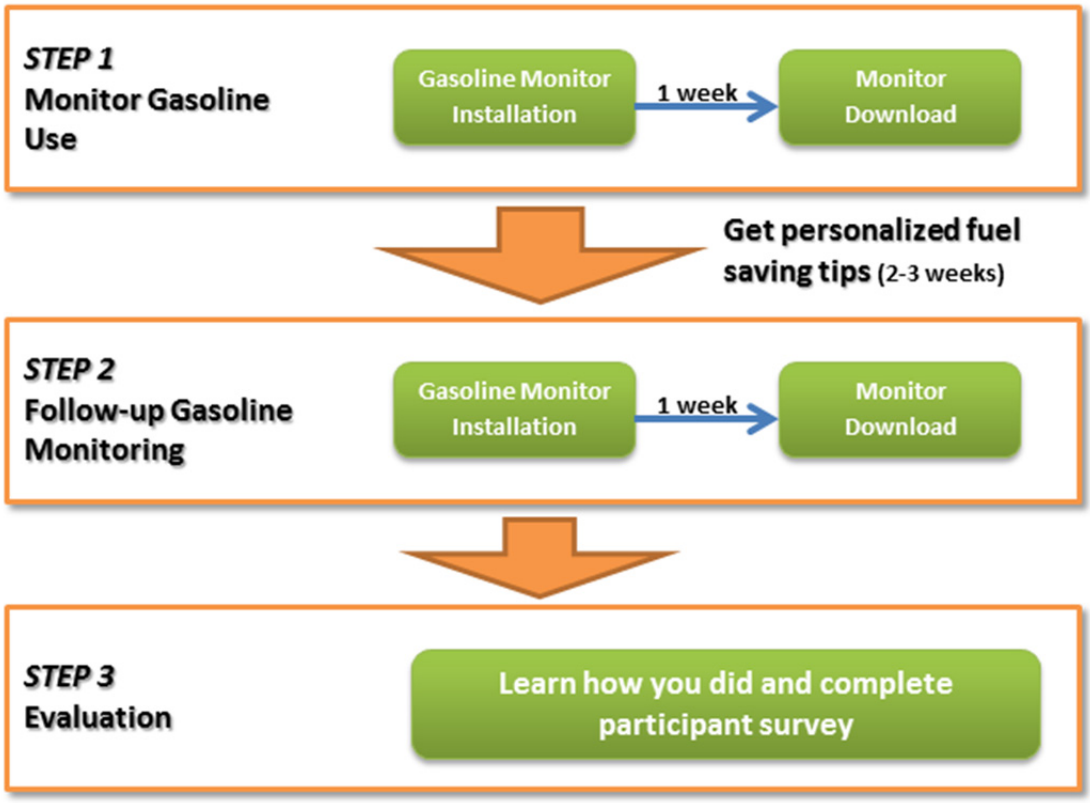
The Vermont Energy Investment Corporation (VEIC) is conducting a pilot study focused on improving the fuel efficiency of driving and we are looking for participants. We will examine how your driving behavior impacts the amount of gas you use, provide tips and suggestions to help you improve this, and then measure how well it worked.

We are looking for volunteers who are the primary driver of a gas-powered vehicle (non-hybrid, 1996 or newer). A data logging device will be plugged into the OBD port of your vehicle, and over the course of about five weeks, we will monitor your driving for two separate one-week periods. Participants will be asked to meet with a VEIC staff person four times (we can come to you) to exchange the device back and forth twice. One of these four exchanges will involve a short, approximately 30 minute, discussion.

For additional information and to volunteer, please see: [Questionnaire URL]

Appendix 2: Transportation Energy Pilot Project Questionnaire

Thank you for your interest in VEIC's transportation energy pilot project. We are requesting volunteers who are the primary driver of a gasoline-powered vehicle (non-hybrid, 1996 or newer). We will collect data on your fuel consumption through a logging device plugged into your vehicle's diagnostic port, which is usually easily accessible under the dashboard. The diagram below shows the overall process and the steps where we will meet with you to install and download the logger. Data collected will be used anonymously to evaluate the effectiveness of this pilot program. No personal information will be reported.



If you are interested in participating, please respond to the following questions. We will contact you to schedule your study times after receiving your form. The study is expected to run from mid-August to November 2013. Submitting this form does not commit you to participate and we cannot guarantee your involvement.

- Name:
- Email:
- Daytime phone number:
- Home city/town:
- Work city/town (if employed):
- Employer (if employed):
- Valid driver's license: y/n

- Vehicle make, model and year
- We are looking for drivers with fairly regular travel patterns from week to week. Do you foresee any significant disruptions to your typical driving routine (e.g. vacation, work travel) over the next three months? We are happy to schedule around these activities if you are able and willing to provide dates.

Please contact the pilot project manager if you have any questions:

Stephanie Morse
VEIC Senior Transportation Analyst
smorse@veic.org
(802) 540-7865

Appendix 3: Coaching Presentation

VERMONT ENERGY
INVESTMENT CORPORATION

Why bother?

Eco-Driving can:

- Help save the planet
- Save you money
- Even save a life

VERMONT ENERGY
INVESTMENT CORPORATION

Other factors

- Keep the fuel cap tightened
  - Avoid fuel evaporation which wastes fuel and releases harmful emissions

VERMONT ENERGY
INVESTMENT CORPORATION

Other factors

- Reduce aerodynamic drag
  - Most significant contributor to vehicle power requirement at speeds above 50 MPH

Source: Certification for Sustainable Transportation at the University of Vermont, Eco-Driving 101 online driver-training program

VERMONT ENERGY
INVESTMENT CORPORATION

Other factors

- Watch cargo weight

- An extra 100 pounds in your vehicle can reduce mileage by up to 2%

VERMONT ENERGY
INVESTMENT CORPORATION

Other factors

- Use air conditioning appropriately
  - More efficient than open windows at speeds above 40 MPH

VERMONT ENERGY
INVESTMENT CORPORATION

Other factors

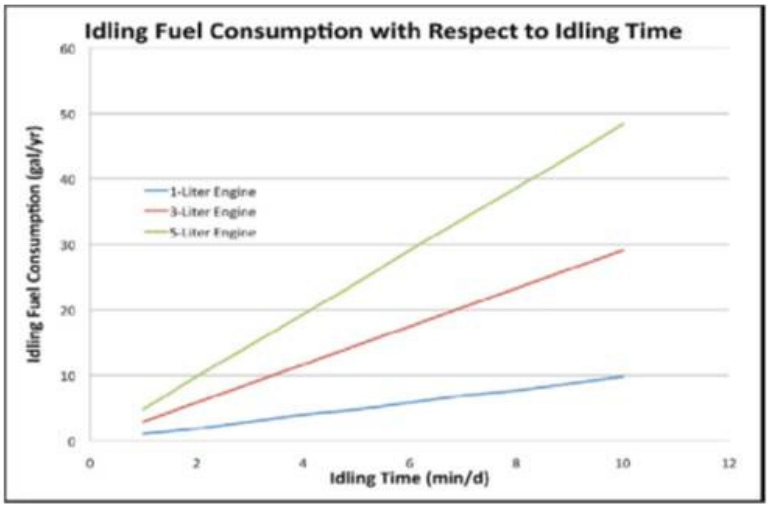
- Use air conditioning appropriately
- Watch cargo weight
- Reduce aerodynamic drag
- Keep the fuel cap tightened

VERMONT ENERGY INVESTMENT CORPORATION

Driving Techniques

- Eliminate unnecessary idling

- Idling = 0 mpg
- Idling is dangerous
- Idling is wasteful
- Idling is illegal under many circumstances
- Idling is usually unnecessary
- Rule of thumb: if you're going to be idling for more than 10-30 seconds, better to turn off your car

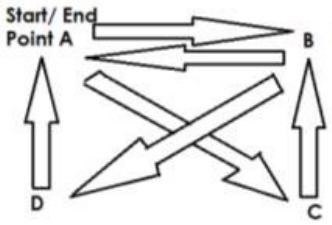


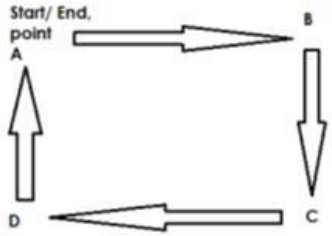
Source: Argonne National Lab

VERMONT ENERGY
INVESTMENT CORPORATION

Driving Techniques

- Plan ahead
  - Develop a list of errands for the week
  - Combine trips and chain errands
  - Group appointments together
  - Plan for the best routes to avoid backtracking





VERMONT ENERGY
INVESTMENT CORPORATION

Driving Techniques

- Keep RPM levels low
  - Shift down at 1000 RPM and up at 2400 RPM
  - Shift into the highest gear/overdrive, as soon as possible (without lugging). Automatics will self-select the optimum gear.
  - Coast when going downhill, and allow yourself to slow down a bit when going uphill. (Don't try to speed up).

VERMONT ENERGY INVESTMENT CORPORATION

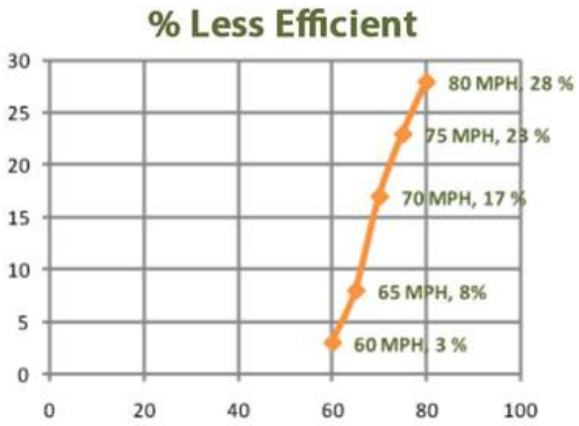
Driving Techniques

- Know when to use cruise control
  - long distances and flat conditions
  - NOT on hills or mountains or in high traffic
  - Using cruise control can be up to 7% more fuel efficient under the right circumstances

VERMONT ENERGY INVESTMENT CORPORATION

Driving Techniques

- Watch your speed
  - Avoid excessive speed
  - Maintain a steady speed
  - Avoid unnecessary acceleration and deceleration



- Advertised mileage typically reached at 55 mph.
- Efficiency decreases significantly with increased speed

Source: Certification for Sustainable Transportation at the University of Vermont, Eco-Driving 101 online driver-training program

VERMONT ENERGY
INVESTMENT CORPORATION

Driving Techniques

- Smart starts and stops
  - Accelerate and decelerate gradually
    - Avoid "jackrabbit" starts and hard breaking
  - Coast and time traffic lights

VERMONT ENERGY INVESTMENT CORPORATION

Driving Techniques

- Smart starts and stops
- Watch your speed
- Know when to use cruise control
- Keep RPM levels low
- Plan ahead
- Eliminate unnecessary idling

Source: Certification for Sustainable Transportation at the University of Vermont, Eco-Driving 101 online driver-training program

VERMONT ENERGY
INVESTMENT CORPORATION

Vehicle Maintenance

- Use the right type of engine oil
  - Using the manufacturer's recommended grade motor oil can improve gas mileage by 1-2%.
  - For example, using 10W-30 motor oil in an engine designed to use 5W-30 motor oil can lower gas mileage by 1-2%.

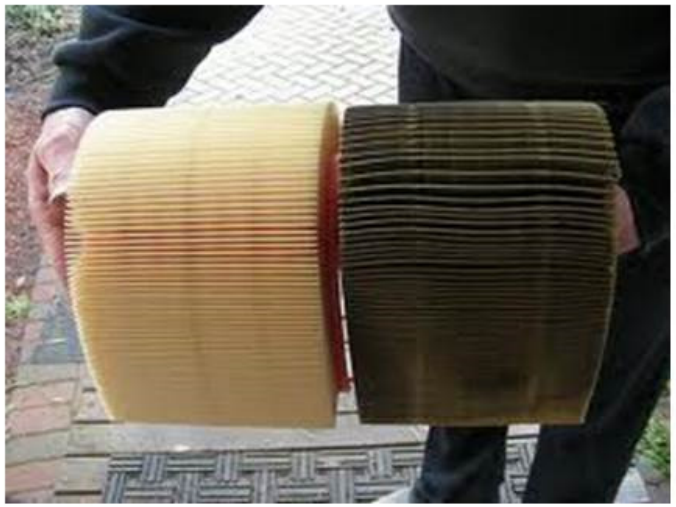
"Energy Conserving" on the API performance symbol indicates that oil contains friction-reducing additives.

VERMONT ENERGY INVESTMENT CORPORATION

Vehicle Maintenance

- Change your air filter regularly

- In a 2009 U.S. DOE study, MGP with a new air filter improved 14% over that with a severely clogged filter.
- Under a more typical state of clog, improvement with a new filter ranged from 2-6%
- Check filters about every 15,000 miles, or annually



VERMONT ENERGY INVESTMENT CORPORATION

Vehicle Maintenance

- Use the right type of tires, keep them aligned, properly inflated, and maintained
  - Up to 3 % improvement in gas mileage by keeping your tires inflated to the proper pressure

TIRE SIZE		TIRE INFLATION PRESSURE kPa (psi) FRONT	REAR
P255/70R16 109S	Ⓐ	180 (26)	180 (26)
	Ⓑ	180 (26)	180 (26)

Ⓐ : TO 5 PASSENGERS
Ⓑ : Ⓐ TO MAX. LOAD OR TRAILER TOWING

PART NO. : MR491176 E

Proper tire pressure for your vehicle is usually found on a sticker in the driver's side door jamb or the glove box, as well as in the owners manual.

AA1Car.com Tire Pressure Inflation Chart

Air pressure changes with temperature. To maintain the recommended inflation pressure, add more air to compensate for colder ambient temperatures
NOTE: For passsenger car and light truck tires only. Never exceed the maximum inflation pressure on the sidewall

Outside Temperature (°F)	OEM Recommended Inflation Pressure in PSI																	
	30	32	34	35	38	40	41	42	45	50	55	60	65	70	75	80	85	90
70	30	32	34	35	38	40	41	42	45	50	55	60	65	70	75	80	85	90
60	31	33	35	36	39	41	42	43	46	51	56	61	67	72	77	82	87	92
50	32	34	36	37	40	42	43	44	47	53	58	63	68	73	79	84	89	94
40	33	35	37	38	41	43	44	45	49	54	59	64	70	75	80	86	91	96
30	34	36	38	39	42	44	46	47	50	55	61	66	72	77	82	87	92	97
20	35	37	39	40	43	46	47	48	51	57	62	67	72	77	82	87	92	97
10	36	38	40	41	45	47	48	49	52	57	62	67	72	77	82	87	92	97
0	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-10	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-20	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-30	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-40	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97

VERMONT ENERGY INVESTMENT CORPORATION

Vehicle Maintenance

- Get regular tune-ups and keep a regular maintenance schedule
  - Fixing a car that is noticeably out of tune or has failed an emissions test can improve its gas mileage by an average of 4%
  - Fixing a serious maintenance problem (such as a faulty oxygen sensor) can improve your mileage by as much as 40%

VERMONT ENERGY INVESTMENT CORPORATION

Vehicle Maintenance

- Get regular tune-ups and keep a regular maintenance schedule
- Use the right type of tires, keep them aligned, properly inflated, and maintained
- Change your air filter regularly
- Use the right type of engine oil

Source: Certification for Sustainable Transportation at the University of Vermont, Eco-Driving 101 online driver-training program

VERMONT ENERGY INVESTMENT CORPORATION

It adds up!

- 169,500,000,000 gallons of fuel / 250,000,000 vehicles
  = 678 gallons of fuel per vehicle
- Possible nationwide savings from just a 10% increase in fuel economy
  = 16,950,000,000 gallons of fuel
- At $3.50 / gallon, that's $59,325,000,000 saved annually
  = $237.00 per vehicle

And using Eco-driving strategies can reduce fuel consumption by:

15% to 25%

Source: Certification for Sustainable Transportation at the University of Vermont, Eco-Driving 101 online driver-training program

VERMONT ENERGY INVESTMENT CORPORATION

Eco-driving is driving with techniques that:

- Save fuel
- Save money
- Reduce environmental impacts
- Improve safety
- Increase vehicle efficiency

And can reduce fuel costs and consumption by:

15% to 25%

Source: Certification for Sustainable Transportation at the University of Vermont, Eco-Driving 101 online driver-training program

VERMONT ENERGY INVESTMENT CORPORATION

VEHICLE MAINTENANCE	DRIVING TECHNIQUES	OTHER FACTORS
☐ Get regular tune-ups	☐ Smart starts and stops	☐ Use air conditioning appropriately
☐ Use the right tires and keep them aligned and inflated properly	☐ Watch your speed	☐ Watch cargo weight
☐ Change your air filter regularly	☐ Use cruise control appropriately	☐ Reduce aerodynamic drag
☐ Use the right type of engine oil	☐ Keep RPM levels low	☐ Keep fuel cap tightened
	☐ Plan ahead	
	☐ Eliminate unnecessary idling	

Appendix 4: Final Data Results by Participant

ID	Vehicle	EPA Estimated Fuel Efficiency (mpg)		Study Periods	Count of Days (days vehicle was driven)	Total Distance (miles)	Daily Average Distance (miles)	Total Fuel Usage (gallons)	Fuel Efficiency relative to EPA Combined Estimate	Average Speed (mph)	Hard Acceleration Events (% of total accelerations)	Hard Braking Events (% of total braking events)	Idle Time (percent of total time vehicle on)	Idle Fuel Usage (gallons)	Fuel Efficiency (mpg)
P1	2006 Subaru Forester, Manual	city: 20 combined: 22 highway: 27	week 1	08/23 - 09/03	5	439.00	87.80	13.21	51%	43	0	3	6	0.28	33.23
			week 2	09/16 - 09/24	3	92.29	30.76	3.19	32%	37	0	3	8	0.08	28.93
			pct. change								0%	0%	33%	-71%	**-12.9%**
P2	2005 Volvo XC 70, Automatic	city: 16 combined: 19 highway: 22	week 1	08/23 - 08/30	5	48.78	9.76	2.96	-13%	16	4	13	21	0.28	16.48
			week 2	09/25 - 10/02	7	58.94	8.42	3.30	-6%	17	1	9	16	0.20	17.86
			pct. change								-75%	-31%	-24%	-29%	**8.4%**
P3	2004 Mazda 6 Sport Wagon, Automatic	city: 17 combined: 19 highway: 24	week 1	08/23 - 09/03	12	485.81	40.48	20.60	24%	30	7	12	13	1.18	23.58
			week 2	09/17 - 09/25	6	77.11	12.85	4.28	-5%	17	7	14	23	0.53	18.02
			pct. change								0%	17%	77%	-55%	**-23.6%**
P4	2005 Toyota Corolla, Automatic	city: 26 combined: 29 highway: 35	week 1	09/04 - 09/13	10	618.10	61.81	16.44	30%	33	7	8	8	0.41	37.60
			week 2	09/25 - 10/04	10	510.39	51.04	13.57	30%	30	4	5	8	0.32	37.61
			pct. change								-43%	-38%	0%	-22%	**0.0%**
P5	2006 Scion xA, Manual	city: 27 combined: 30 highway: 34	week 1	09/04 - 09/12	8	323.37	40.42	8.40	28%	29	3	6	7	0.07	38.50
			week 2	09/18 - 09/30	12	511.20	42.60	13.53	26%	28	3	7	8	0.16	37.78
			pct. change								0%	17%	14%	129%	**-1.9%**
P6	2005 Ford Focus Station Wagon, Automatic	city: 22 combined: 25 highway: 29	week 1	09/06 - 09/13	7	337.82	48.26	11.60	16%	30	10	14	13	0.71	29.12
			week 2	10/06 - 10/13	7	372.55	53.22	12.94	15%	31	5	12	11	0.63	28.79
			pct. change								-50%	-14%	-15%	-11%	**-1.1%**
P7	2010 Subaru Forester, Manual	city: 20 combined: 22 highway: 27	week 1	09/30 - 10/09	9	329.35	36.59	12.90	16%	26	5	12	14	0.55	25.53
			week 2	10/22 - 10/31	8	304.04	38.01	11.31	22%	29	4	10	11	0.35	26.88
			pct. change								-20%	-17%	-21%	-36%	**5.3%**
P8	2003 Dodge Dakota Pickup, Automatic	city: 13 combined: 14 highway: 16	week 1	10/03 - 10/14	8	71.11	8.89	3.57	42%	17	2	16	29	0.21	19.92
			week 2	10/28 - 11/04	7	66.79	9.54	3.44	39%	13	1	10	32	0.28	19.42
			pct. change								-50%	-38%	10%	33%	**-2.5%**
P9	2002 Subaru Forester, Manual	city: 19 combined: 21 highway: 25	week 1	10/09 - 10/21	9	306.89	34.10	10.35	41%	34	2	11	8	0.19	29.65
			week 2	11/04 - 11/13	6	345.17	57.53	11.53	43%	34	1	8	8	0.21	29.94
			pct. change								-50%	-27%	0%	11%	**1.0%**
P10	2003 Subaru Forester, Automatic	city: 19 combined: 21 highway: 24	week 1	10/15 - 10/23	6	117.36	19.56	4.91	14%	21	8	12	12	0.21	23.90
			week 2	11/06 - 11/13	6	173.05	28.84	6.42	28%	24	2	6	10	0.25	26.95
			pct. change								-75%	-50%	-17%	19%	**12.8%**
P11	2006 Kia Rio, Manual	city: 27 combined: 29 highway: 32	week 1	10/15 - 10/22	7	152.74	21.82	5.51	-4%	21	0	6	16	0.37	27.72
			week 2	11/01 - 11/12	12	161.73	13.48	6.52	-14%	15	0	7	18	0.71	24.81
			pct. change								0%	17%	13%	92%	**-10.5%**
AVERAGE									21%		-33%	-15%	6%	5%	**-2.3%**

Appendix 5: Example Trip Log

Trip Id	Date	Duration	Trip Distance (mi)	Fuel Consumed (gal)	% Time Idle	Average Speed (MPH)	Hard Acceleration (% of total)	Hard Braking (% of total)	Number of Idle Events (over 1 min.)	Fuel Efficiency (mpg)
1.886	October 01 2013 07:37:32 AM	0:47:35	21.84	0.78	18%	27.53	5	9	6	28.00
2.886	October 01 2013 12:12:50 PM	0:12:22	6.38	0.22	6%	30.89	7	11	0	29.00
3.886	October 01 2013 04:21:49 PM	0:11:54	2.55	0.13	35%	12.83	4	8	4	19.62
4.886	October 01 2013 04:36:12 PM	0:33:32	14.3	0.58	16%	25.57	1	17	4	24.66
5.886	October 01 2013 05:13:52 PM	0:03:59	1.59	0.06	0%	23.79	0	17	0	26.50
6.886	October 01 2013 05:22:14 PM	0:04:05	1.61	0.05	1%	23.62	0	0	0	32.20
7.886	October 02 2013 07:40:29 AM	0:16:12	9.78	0.33	1%	36.2	3	9	0	29.64
8.886	October 02 2013 11:58:21 AM	0:10:58	3.87	0.17	20%	21.16	13	18	2	22.76
9.886	October 02 2013 12:10:06 PM	0:05:40	1.06	0.06	43%	11.2	0	10	2	17.67
10.886	October 02 2013 12:32:34 PM	0:02:53	0.39	0.03	27%	8.05	14	0	0	13.00
11.886	October 02 2013 12:40:46 PM	0:05:58	1.62	0.07	34%	16.21	9	17	2	23.14
12.886	October 02 2013 01:01:05 PM	0:07:25	3.34	0.12	12%	26.98	0	7	0	27.83
13.886	October 02 2013 06:03:00 PM	0:15:48	9.77	0.34	1%	37.07	3	8	0	28.74
14.886	October 03 2013 07:45:33 AM	0:18:39	9.82	0.36	10%	31.58	3	13	1	27.28
15.886	October 03 2013 09:29:58 AM	0:05:38	3.01	0.12	6%	31.98	15	40	0	25.08
16.886	October 03 2013 09:37:39 AM	0:15:46	6.41	0.25	22%	24.35	9	22	2	25.64
17.886	October 03 2013 11:18:21 AM	0:17:15	3.95	0.2	38%	13.73	18	13	3	19.75
18.886	October 03 2013 12:16:12 PM	0:08:38	0.86	0.07	62%	5.99	8	33	5	12.29
19.886	October 03 2013 12:30:06 PM	0:14:18	5.22	0.2	6%	21.87	3	8	0	26.10
20.886	October 03 2013 12:46:31 PM	0:27:18	11.98	0.45	14%	26.31	8	21	1	26.62
21.886	October 03 2013 04:46:00 PM	0:12:02	6.14	0.22	7%	30.55	0	15	0	27.91
22.886	October 03 2013 06:02:04 PM	0:19:12	10.13	0.35	4%	31.63	2	7	0	28.94
23.886	October 04 2013 06:06:40 AM	0:09:33	3.67	0.15	20%	23.01	0	27	1	24.47
24.886	October 04 2013 07:09:20 AM	0:01:47	0.37	0.03	29%	12.44	0	50	0	12.33
25.886	October 04 2013 07:38:16 AM	0:01:49	0.04	0.01	72%	1.29	0	0	1	4.00

Trip Id	Date	Duration	Trip Distance (mi)	Fuel Consumed (gal)	% Time Idle	Average Speed (MPH)	Hard Acceleration (% of total)	Hard Braking (% of total)	Number of Idle Events (over 1 min.)	Fuel Efficiency (mpg)
26.886	October 04 2013 04:39:06 PM	0:07:07	3.68	0.15	1%	30.97	17	15	0	24.53
27.886	October 05 2013 11:57:08 AM	0:37:29	21.73	0.81	3%	34.78	7	17	0	26.83
28.886	October 05 2013 03:29:10 PM	0:02:55	0.55	0.04	21%	11.19	0	14	0	13.75
29.886	October 05 2013 03:53:00 PM	0:21:34	7.3	0.32	24%	20.29	7	18	4	22.81
30.886	October 05 2013 04:48:18 PM	0:07:50	1.86	0.1	25%	14.22	0	0	2	18.60
31.886	October 05 2013 05:32:44 PM	0:15:31	2.68	0.19	32%	10.36	6	9	4	14.11
32.886	October 05 2013 05:51:59 PM	0:03:47	0.76	0.03	38%	11.93	0	0	1	25.33
33.886	October 05 2013 07:51:53 PM	0:07:37	3.19	0.13	7%	25.05	0	7	0	24.54
34.886	October 05 2013 08:08:44 PM	0:17:16	10.16	0.38	1%	35.29	0	11	0	26.74
35.886	October 06 2013 12:30:19 PM	0:29:56	19.1	0.71	10%	38.26	4	7	2	26.90
36.886	October 06 2013 06:37:20 PM	0:31:13	13.56	0.62	11%	26.05	9	11	2	21.87
37.886	October 06 2013 07:21:20 PM	0:04:40	2.03	0.1	3%	25.99	0	14	0	20.30
38.886	October 07 2013 09:25:43 AM	0:18:18	10.08	0.32	1%	33.01	0	5	0	31.50
39.886	October 07 2013 09:51:21 AM	0:33:28	12.71	0.49	10%	22.78	5	11	1	25.94
40.886	October 07 2013 10:58:06 AM	0:15:11	4.09	0.19	14%	16.15	3	11	1	21.53
41.886	October 07 2013 11:34:49 AM	0:21:12	6.74	0.29	16%	19.07	8	24	3	23.24
42.886	October 07 2013 04:19:16 PM	0:29:08	9.3	0.45	14%	19.14	1	0	2	20.67
43.886	October 07 2013 04:58:28 PM	0:10:31	5.19	0.2	5%	29.58	0	5	0	25.95
44.886	October 08 2013 06:02:08 AM	0:18:19	9.89	0.33	13%	32.35	6	13	2	29.97
45.886	October 08 2013 07:30:29 AM	0:05:51	1.86	0.09	23%	19.07	10	17	1	20.67
46.886	October 08 2013 07:38:02 AM	0:06:42	2.75	0.11	12%	24.58	12	17	1	25.00
47.886	October 08 2013 04:25:35 PM	0:31:02	13.73	0.56	15%	26.53	6	21	3	24.52
48.886	October 08 2013 05:49:12 PM	0:15:07	8.44	0.27	5%	33.48	11	11	0	31.26
49.886	October 08 2013 08:57:46 PM	0:15:53	8.52	0.32	2%	32.15	0	10	0	26.63
50.886	October 09 2013 07:39:27 AM	0:16:38	9.75	0.35	4%	35.15	3	8	0	27.86

Trip Id	Date	Duration	Trip Distance (mi)	Fuel Consumed (gal)	% Time Idle	Average Speed (MPH)	Hard Acceleration (% of total)	Hard Braking (% of total)	Number of Idle Events (over 1 min.)	Fuel Efficiency (mpg)
51.886	October 22 2013 04:51:12 PM	1:00:58	42.97	1.4	8%	42.28	4	9	4	30.69
52.886	October 22 2013 07:45:22 PM	0:56:41	37.53	1.21	3%	39.72	1	4	0	31.02
53.886	October 23 2013 05:24:11 AM	0:17:10	9.91	0.31	4%	34.59	3	14	0	31.97
54.886	October 23 2013 07:36:51 AM	0:15:32	6.4	0.25	13%	24.71	0	13	0	25.60
55.886	October 23 2013 02:36:50 PM	0:14:27	6.39	0.26	13%	26.5	9	10	1	24.58
56.886	October 23 2013 03:09:33 PM	0:28:11	14.14	0.5	8%	30.08	5	13	1	28.28
57.886	October 23 2013 06:12:37 PM	0:03:56	1.6	0.08	7%	24.38	0	11	0	20.00
58.886	October 23 2013 06:19:38 PM	0:03:52	1.62	0.05	7%	25.05	0	0	0	32.40
59.886	October 24 2013 05:29:02 AM	0:16:44	9.91	0.33	6%	35.5	12	21	0	30.03
60.886	October 24 2013 07:26:26 AM	0:02:46	0.48	0.04	32%	10.39	0	20	1	12.00
61.886	October 24 2013 07:35:58 AM	0:13:26	5.99	0.23	9%	26.72	7	30	1	26.04
62.886	October 24 2013 10:20:57 AM	0:05:56	3.19	0.12	4%	32.17	18	8	0	26.58
63.886	October 24 2013 12:59:16 PM	0:06:07	3.17	0.14	10%	30.98	8	11	0	22.64
64.886	October 24 2013 05:04:59 PM	0:17:04	9.76	0.38	2%	34.29	10	7	0	25.68
65.886	October 25 2013 07:40:49 AM	0:16:32	9.76	0.34	2%	35.38	6	5	0	28.71
66.886	October 25 2013 05:03:01 PM	0:17:28	9.77	0.37	4%	33.52	8	5	0	26.41
67.886	October 28 2013 07:26:58 AM	0:41:04	18.1	0.64	11%	26.44	4	6	3	28.28
68.886	October 28 2013 08:16:48 AM	0:02:03	0.48	0.02	9%	13.87	0	0	0	24.00
69.886	October 28 2013 11:39:04 AM	0:02:13	0.51	0.05	10%	13.7	0	17	0	10.20
70.886	October 28 2013 11:45:03 AM	0:02:01	0.5	0.02	4%	14.68	17	40	0	25.00
71.886	October 28 2013 03:49:46 PM	0:15:14	4.83	0.24	9%	19	3	3	0	20.13
72.886	October 28 2013 04:28:37 PM	0:24:52	12.28	0.48	8%	29.62	2	5	1	25.58
73.886	October 28 2013 04:57:43 PM	0:04:40	1.61	0.06	15%	20.63	0	0	0	26.83
74.886	October 29 2013 07:08:23 AM	0:30:49	11.19	0.47	18%	21.78	5	10	3	23.81

Trip Id	Date	Duration	Trip Distance (mi)	Fuel Consumed (gal)	% Time Idle	Average Speed (MPH)	Hard Acceleration (% of total)	Hard Braking (% of total)	Number of Idle Events (over 1 min.)	Fuel Efficiency (mpg)
75.886	October 29 2013 07:41:06 AM	0:15:23	3.48	0.17	23%	13.55	2	3	3	20.47
76.886	October 29 2013 02:38:51 PM	0:18:24	9.8	0.41	12%	31.91	3	11	2	23.90
77.886	October 29 2013 03:02:59 PM	0:02:01	0.8	0.03	2%	23.68	0	20	0	26.67
78.886	October 29 2013 05:27:53 PM	0:29:48	15.97	0.61	10%	32.14	1	9	2	26.18
79.886	October 30 2013 07:24:30 AM	0:25:15	11.22	0.41	13%	26.65	4	10	1	27.37
80.886	October 30 2013 07:52:19 AM	0:16:49	3.34	0.17	41%	11.91	10	6	5	19.65
81.886	October 30 2013 11:40:46 AM	0:02:21	0.56	0.05	11%	14.14	0	17	0	11.20
82.886	October 30 2013 11:44:48 AM	0:02:17	0.58	0.03	15%	15.13	0	20	0	19.33
83.886	October 30 2013 04:00:21 PM	0:16:08	4.61	0.22	16%	17.13	0	11	2	20.95
84.886	October 30 2013 04:23:22 PM	0:02:02	0.03	0.01	81%	0.87	0	0	1	3.00
85.886	October 30 2013 04:26:13 PM	0:40:40	15.21	0.6	21%	22.43	1	13	3	25.35
86.886	October 31 2013 06:01:00 AM	0:17:31	9.94	0.32	7%	34.01	3	9	0	31.06
87.886	October 31 2013 07:40:43 AM	0:18:13	6.41	0.29	22%	21.1	3	30	4	22.10

Appendix 6: Emails Communicating Findings to Participants

Thank you for your participation in VEIC's Transportation Energy Assessment Pilot Project. It was great to meet you, and I appreciate your time and enthusiasm for this research. I have compiled all of the results and have attached two files for you. One (titled with your name) is a table of all participants' results, showing summary statistics from each time period as well as a calculated percent change where appropriate. I have highlighted your results, since I removed names from this table. The second file (your name.log) is the log of all of your trips, including both time periods. I have inserted a grey line between the two time periods for quick reference.

[Insert individual findings paragraph]

Here is the link to the survey we discussed: [survey URL]

I would greatly appreciate you taking a few minutes to fill it out. I anticipant the information you provide will be helpful in understanding our results as well as in improving the research if we are able to move forward with it.

Thank you again and please let me know if you have any questions or would like to discuss any of your results. And of course, keep up the eco-driving!

Stephanie

Individual Findings Paragraphs:

P1:

As we discussed, you are clearly a very efficient driver, perhaps with little room for improvements in your fuel efficiency. While most participants showed fuel efficiencies higher than the EPA estimates for their vehicles, you showed some of the biggest gaps (51% and 32% over the EPA combined estimate). However, with that said, we did observe a decrease in efficiency between your two time periods. With such low rates of hard accelerating, hard braking, and idling, I have to assume this is the result of the type of driving you did in the two time periods. Your second period had a lower average speed and significantly fewer miles per day, leading me to believe that you did more in-town driving and less highway, long trip type driving. This is a very short time period and small sampling of your driving to draw any firm conclusions from, but that is the best I can come up with. Do you have any thoughts that could potentially add clarity to this?

P2:

Congratulations – you are one of the only participants to show improvements in all of the main statistics I was comparing! You had a lower rate of hard accelerations, hard braking, and idling, resulting in an improved fuel efficiency. I know that the Eco-Driving powerpoint that we went through stated potential gains of 15-25% in efficiency, but as I dig into this further, I'm actually starting to think this is overstated. I think your improvement of 8.4% is fantastic, and this is

probably more in the range of a reasonable expectation for improvements resulting from eco-driving. So, great job! Thank you!

P3:

So, there was a pretty sizable decrease in fuel efficiency between your two time periods. My initial reaction is that this must be the result of the type of driving you did. In your second period, you had significantly fewer miles and a much lower average speed. I interpret this as much more in-town driving and many fewer long, highway type trips. Does that seem right? And actually, if we look at your first period as predominantly highway/combined and your second period as city/combined, both periods are right in line with the EPA estimates for fuel efficiency for your vehicle. It would be interesting to compare like trips (e.g. trips under 5 miles with an average speed less than 15 mph, or something like that) in your data, and compare the fuel efficiency between those. Future research I guess…

P4:

Your results were very interesting. You were one of the only participants to show improvements in all of the behavior measures (e.g. hard accelerations and braking), but not show an improvement in fuel efficiency. You did have a slightly slower average speed and fewer miles per day in your second period – perhaps you had a bit more in-town driving and less highway driving. If that were the case, it could make sense that you maintained the same fuel efficiency even while improving your eco-driving. In any case, you (and your son!) were very consistent between the two periods, and very consistently efficient, so that is great to see!

P5:

Unfortunately, we did not see an improvement in fuel efficiency between your two time periods. However, you appear to be a very efficient driver regularly (your fuel efficiency for both time periods was significantly higher than the EPA estimates for your vehicle) and your reduction in fuel efficiency was very small, and likely insignificant.

P6:

I am finding your results quite puzzling. You improved in all of the behavioral measures we tracked (accelerations, braking, idling), but your fuel efficiency decreased. Granted, the change in your fuel efficiency was very minor and likely insignificant, but with the behavioral changes, I would have expected to see an improvement. Can you identify any other changes that could have impacted this? Perhaps you were pulling your trailer more in the second period? As you're thinking about the design of your own study, this would be something to keep in mind ☺ In any case, the behavioral changes are great to see, and hopefully we can identify why they didn't result in improved efficiency.

P7:

Congratulations – you are one of the only participants to show improvements in all of the main statistics I was comparing! You had a lower rate of hard accelerations, hard braking, and idling, resulting in an improved fuel efficiency. I think we discussed that the stat presented in the eco-driving powerpoint—that eco-driving can result in 15-25% improvements in fuel efficiency—might be a bit overstated. I think your improvement of 5.3% is fantastic, and this is probably

more in the range of a reasonable expectation for improvements resulting from eco-driving. So, great job! Thank you!

P8:

Your results were very interesting. It looks like you were mindful of your accelerating and braking, and I saw a reduction in the percent of those that were 'hard'. However, your idling time increased a little bit. Were you maybe showing your truck more? I know you said you were very careful about that, so I was surprised to see that increase. We did see a slight reduction in your fuel efficiency, but it was very small, so I wouldn't worry too much about that. I think you'll be in good shape if you keep working on avoiding hard starts and stops, keep a close eye on avoiding idling, and hopefully you'll be able to sell your truck ☺

P9:

Congratulations – you were able to improve your fuel efficiency ever so slightly! As we discussed, you appear to be a very efficient driver regularly (you are beating the EPA combined estimate for your vehicle by over 40%!), but you managed to get a smidge better. You reduced your rate of hard starts and stops, your idling stayed pretty much the same, and your efficiency improved by 1%. I was wondering about your snow tires though. Do you remember when during your second data collection period you had them put on, and how long you were carrying your regular tires around with you? Because of the increased friction, snow tires will likely reduce your fuel efficiency, especially if you have the added weight of carrying your other tires around with you ☺ So, maybe you could have seen a bigger improvement otherwise?

P10:

Congratulations, you were the big winner with the largest fuel efficiency improvements. However, I do have to wonder if this was the result of the longer trip you made (with a different driver!) compared to the in-town trips of your first study period? There was a significant reduction in the percentage of hard starts and stops (and idling), but unfortunately, I was not able to obtain the rate or g-force defining the threshold for "hard". Given the change in your driving patterns between the two periods, it would be interesting to compare like trips (e.g. trips under 5 miles with an average speed less than 15 mph, or something like that) in your data, and compare the fuel efficiency between those. Future research I guess…

P11:

While you continue to have good driving behavior, we did see a slight increase in hard braking and idling in the second time period, as well as decrease in fuel efficiency. I'm not sure how to explain this, but I think your and your husband's mindfulness of fuel efficiency, and the fact that you are able to keep your overall driving at such low levels, must be more than half the battle. I'd be very curious to hear if you notice anything interesting in your trip log.

Appendix 7: Survey Responses

VEIC Transportation Energy Assessment Pilot Study

Did you see any benefit from participating in this study?

Answer Options	Response Percent	Response Count
Not at all	0.0%	0
Slight benefit	50.0%	3
Significant benefit	50.0%	3
Comment		5
answered question		6
skipped question		0

Number	Comment	Categories
1	At the very least, it confirmed my personal driving theories, and provides data for future studies and research.	
2	I picked up a number of tips to improve my driving efficiency	
3	It increased my awareness of my driving habits.	
4	It made me aware of ways I'm already driving efficiently (great to have that kind of feedback) and ways to improve. I do keep them in mind.	
5	I am certainly more aware of my driving habits. But I don't expect to see a long term gain in my efficiency (party since I was efficient to begin with)	

Would you be interested in participating in another round of the transportation energy assessment in 6-12 months?

Answer Options	Response Percent	Response Count
Yes	50.0%	3
No	0.0%	0
Maybe	50.0%	3
Comment		3
answered question		6
skipped question		0

Number	Comment	Categories
1	Given the amount and type of driving I do, it would only be useful if I had a longer time for each monitoring period	
2	Perhaps if there was some sort of incentive.	
3	I may not be in VT...but if I am sure.	

Would you recommend this study to a friend?

Answer Options	Response Percent	Response Count
Yes	83.3%	5
No	0.0%	0
Maybe	16.7%	1
Comment		1
answered question		6
skipped question		0

Number	Response Date	Comment	Categories
1	See above comment.		

Before this study, how frequently did you practice the following Vehicle Maintenance tips?

Answer Options	never	infrequently	frequently	always	Response Count
Get regular tune-ups	0	2	3	1	6
Use the right tires and keep them aligned and inflated	0	0	3	3	6
Change your air filter regularly	0	1	3	2	6
Use the right type of engine oil	0	0	0	6	6
answered question					6
skipped question					0

As a result of this study, how frequently will you practice the following Vehicle Maintenance tips?

Answer Options	never	infrequently	frequently	always	Response Count
Get regular tune-ups	0	0	4	2	6
Use the right tires and keep them aligned and inflated	0	0	2	4	6
Change your air filter regularly	0	0	2	4	6
Use the right type of engine oil	0	0	0	6	6
				answered question	6
				skipped question	0

Before this study, how frequently did you practice the following Driving Technique tips?

Answer Options	never	infrequently	frequently	always	Response Count
Smart starts and stops	0	0	5	1	6
Watch your speed	0	1	4	1	6
Use cruise control appropriately	1	0	2	2	5
Keep RPM levels low	0	1	3	2	6
Plan ahead	0	1	3	2	6
Eliminate unnecessary idling	0	0	2	4	6
				answered question	6
				skipped question	0

As a result of this study, how frequently will you practice the following Driving Technique tips?

Answer Options	never	infrequently	frequently	always	Response Count
Smart starts and stops	0	0	5	1	6
Watch your speed	0	0	4	2	6
Use cruise control appropriately	1	0	1	3	5
Keep RPM levels low	0	0	3	3	6
Plan ahead	0	0	3	3	6
Eliminate unnecessary idling	0	0	0	6	6
				answered question	6
				skipped question	0

Before this study, how frequently did you practice the following tips?

Answer Options	never	infrequently	frequently	always	Response Count
Use air conditioning appropriately	0	0	1	5	6
Watch cargo weight	0	1	3	2	6
Reduce aerodynamic drag	0	2	3	1	6
Keep fuel cap tightened	0	0	1	5	6
				answered question	6
				skipped question	0

As a result of this study, how frequently will you practice the following tips?

Answer Options	never	infrequently	frequently	always	Response Count
Use air conditioning appropriately	0	0	1	5	6
Watch cargo weight	0	0	3	3	6
Reduce aerodynamic drag	0	0	5	1	6
Keep fuel cap tightened	0	0	0	6	6
				answered question	6
				skipped question	0

How likely are you to continue to practice the Eco-Driving behaviors you learned in this study?

Answer Options	Response Count
Not at all likely	0
Somewhat likely	0
Likely	1
Absolutely	5
NA - I did not learn anything new	0
answered question	*6*
skipped question	*0*

How would you suggest we improve this study in the future? (please check all that apply)

Answer Options	Response Count
More clearly explain expectations	1
Expand Eco-driving coaching meeting	0
Just provide tips and do not include coaching	0
Provide more detailed analysis of my driving behavior	2
Other (please specify)	3
answered question	*2*
skipped question	*4*

Number	Response Date	Other (please specify)	Categories
1	Dec 10, 2013 3:07 PM	I will admit that I forgot what the inital time periods were for the recordings of my driving habits, or where I went, so when the final research was presented, I really had to think back. It could be useful to have the drivers keep a very simple log of their trips while the recording device is in their car; simply state, "in-town driving today", or "interstate trip for 2 hours", etc. While the device will record that data, the information could be useful to review once the final analysis has been completed.	
2	Dec 5, 2013 3:51 PM	None of the above. I'm not sure how you could improve. I'm still confused by my idling data but that's up to me to figure out.	
3	Nov 20, 2013 12:37 AM	Thought it was just right.	

Thank you for participating in this study and for filling out this survey. Do you have any comments that you'd like to add about your experience in

Answer Options	Response Count
	3
answered question	3
skipped question	3

Number	Response Date	Response Text	Categories
1	Dec 10, 2013 3:07 PM	Stephanie was great to work with, and I personally believe that since transportation, and particularly transportation emissions, are such a large contributor to the world's climate change status, that more studies like this should be conducted. From the research gathered, I would highly encourage "eco-driving awareness workshops" to educate "typical drivers" about how they can save money, and emissions. I know there are some such intiatives, but given the love N. American's have for driving, I don't think there can be too many right now!	
2	Dec 6, 2013 3:07 PM	I'm not sure what conclusions you're going to draw from the data. Maybe a longer monitoring period would work. It also could be that the participants are a self-selecting group, and aren't the ones that really need the coaching.	
3	Dec 5, 2013 3:51 PM	Stephanie had great customer service skills! Very friendly, punctual and communicative.	