VEHICLE MONITORING TECHNOLOGY: OPPORTUNITIES TO IMPROVE THE ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY OF A SKI RESORT FLEET

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Introduction

Tourism literature is replete with accounts of adverse environmental impacts caused by tourism development, with mass tourism destinations facing the brunt of heavy criticism. This has led research attention toward small-scale, environmentally and culturally appropriate forms of tourism as a means to achieve sustainability, and attention away from the challenging task of resolving how mass tourism can be made more sustainable (Butler 1999, Bramwell et al. 1996, Wall 1996, Wheeller 1993). Given the popularity and demand for mass tourism, it can confidently be assumed that it will not easily nor quickly be replaced by these 'alternative' tourism forms, thereby highlighting the urgent call for sustainability efforts to centre on existing and future mass tourism markets. Related to this fundamental issue is the question of how the effects of tourism can be monitored and assessed to help determine how sustainability might be achieved.

Climate change is "the greatest challenge to the sustainability of the global tourism industry in the 21st century", according to the United Nations World Tourism Organization (UNWTO), United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) (UNWTO et al. 2008, pp. 22). Particularly vulnerable to climate change is the multi-billion dollar ski tourism sector. Projected decreases in natural snow availability due to warmer temperatures may lead to a host of impacts including decreased season length, increased operating costs for snowmaking, as well as reduced visitation, associated revenue and job losses. Global mean concentrations of the greenhouse gas carbon dioxide (CO_2), which results from the burning of fossil fuels, is one of the largest contributors (75%) to current radiative forcing (a concept used for quantitative comparisons of the strength of human agents in causing climate change) (Forster et al. 2007). The passion many Canadians have for skiing and snowboarding and the climate conditions needed to enjoy this mass tourism product, presents an innovative avenue to raise awareness of this vulnerability and foster sustainable behavioural changes that can reduce CO_2 emissions and climate altering impacts.

By demonstrating the usefulness of in-vehicle engine monitoring technology, this paper will emphasize the potential to successfully reduce CO_2 emissions that are generated by the operation of a ski resort fleet in Ontario, Canada. Baseline data was acquired on driving behaviour and engine idling to assess opportunities to achieve fuel efficiency and emissions reductions through the adoption of eco-driver training. Best practices from this project will be used as a model for additional ski resort operations, with the aim of improving the industry's environmental performance throughout Canada. This is the first known study to quantify the relationship between the economic and environmental impacts of driver behaviour within a tourism setting, and represents a novel means for ski resort operations to enhance their environmental and economic sustainability through a measurable reduction in harmful vehicle emissions.

Background and Context

Road transport forms an important component of greenhouse gas emissions in Canada, with vehicle use, fuel consumption and its associated CO_2 emissions projected to increase well into the future (Beusen et al. 2009, International Energy Agency 2005, Saboohi & Farzaneh 2009). Reducing fuel consumption by educating drivers on how to change their driving behaviour has great potential to be a cost-efficient approach to reducing energy use, improve the quality of the local environment and lower fuel costs. Ecological, economical and safe driving (eco-driving) is a relatively new concept which was first developed and integrated into driver training courses by the German Federation of Driving Instructor Associations in the mid-1990s (Dandrea 1996). There are three key facets that govern eco-driving. (1) Smooth and gradual acceleration and deceleration. Driving based on sudden acceleration/deceleration uses approximately 33-40% more fuel (Ericsson 2001, NRCan 2009a, Saboohi & Farzaneh 2009, Thew 2007). (2) Maintaining a steady speed by anticipating traffic flow while adhering to the posted speed limits. While each vehicle reaches its optimal fuel economy at different speeds, fuel efficiency decreases 10-23% at speeds above 90 kilometers per hour (60 miles per hour) (NRCan 2009a, West et al. 1999). (3) Avoid idling by turning off the engine when not in use. Idling is the most inefficient use of fuel at zero kilometers per liter of gas. More than 10 seconds of idling consumes more fuel than would have been used if the engine was turned off and restarted (NRCan 2009b).

Although there are very limited studies that have evaluated eco-trained drivers, the results are promising. A literature review for the European Conference of Ministers of Transport by the International Energy Agency (2005) found an average estimated reduction of fuel consumption of 5% for OECD (Organization for Economic Cooperation and Development) regions. Since then, additional studies have recorded 2% decrease in fuel consumption 12 months after corporate bus drivers were trained (Wahlberg 2007). Zarkadoula et al. (2007) noted a decrease of 18% for two bus drivers and an average decrease of 10% for all bus drivers during a post training monitoring period of two months. Beusen et al. (2009) stated average fuel consumption four months after the course fell 5%, with most drivers showing an immediate improvement in fuel consumption. This is also the only known study to detail the influence of eco-driver training on idling, which realized an average decrease of 1.5%.

Fostering behaviour change is central to achieving sustainability (Schmuck & Vlek 2003, Butler 1999, Bramwell et al. 1996) and individuals and businesses must be encouraged to engage in an array of activities, such as altering transportation habits. In order to quantify the potential benefits of eco-driver training toward improving resort sustainability, baseline data was acquired prior to the behavioural intervention. As part of a three step process (pre-eco-driver training; eco-driver training; post-eco-driver training), this paper highlights the results of the first phase. This project pioneers the use of vehicle monitoring technology within a tourism context to assess opportunities to harness eco-driver training to improve fuel efficiency and emissions reductions associated with the operation of a fleet of vehicles at a ski resort. This model holds promise for extension into other ski resorts in Canada, as well as other nations and types of tourism destinations.

Method

Blue Mountain Ski Resorts Limited (BMR), located in the UNESCO Biosphere Reserve of the Niagara Escarpment in Ontario, Canada, was chosen as the site to launch this research. With a strong influence on tourism in the region, BMR operates the largest public ski resort in the province, hosting over half a million skiers annually, and employing more than 2,000 local area residents. Recognizing the dependence of winter sports on this fragile natural ecosystem and the potential impacts of climate change on the tourist experience, BMR agreed to have on-board data loggers installed in resort vehicles to monitor staff driving behaviour during the winter season before (2009-2010) and after (2010-2011) the implementation of an eco-driver training course. To limit the influence these devices may have on driver behaviour, the staff was notified of the installation but details on which driving parameters were being recorded, as well as the purpose of the study, was not made available.

The first phase of the project began in December 2009 with the programming and installation of on-board data loggers (CarChip®) into 14 light and medium class fleet vehicles. Information on each vehicle was recorded, including vehicle year, manufacturer and model, engine size and fuel type (Table 1). The device was installed out of sight of the driver by plugging the device into the On-board Diagnostic (OBD) port found under the dashboard.

Table 1. Vehicle details

Vehicle	Vehicle Model	Fuel Type	Engine Size (L)	Year	Department/ Vehicle Function
1	Toyota Tundra	Unleaded	4.7	2007	Operations
2	Ford F150	Unleaded	5.4	2002	Operations
3	Toyota Yaris	Unleaded	1.5	2010	Accounting
4	Chevrolet Venture Van	Unleaded	3.4	1999	Information Technology
5	Chevrolet Express Van	Unleaded	5.7	2000	Grounds/ Maintenance
6	GMC Sierra	Unleaded	5.4	2004	Grounds/ Maintenance
7	Ford 250 4x4	Unleaded	4.6	1998	Grounds/ Maintenance
8	GMC Sierra	Unleaded	5.0	1997	Grounds/ Maintenance
9	Ford CTV Bus	Diesel	7.5	1995	Shuttle
10	Ford Senator 24-passenger	Diesel	6.0	2005	Shuttle
11	Ford E450 Bus	Diesel	7.3	1999	Shuttle
12	GMC Safari Van	Unleaded	4.3	2002	Security
13	Dodge Caravan	Unleaded	3.0	2000	Security
14	Honda Fit	Unleaded	1.5	2008	Information Technology

Once installed the CarChips® continuously read the driving and engine performance data from the vehicle's on-board computers and stores the data on an internal memory card. Selected parameters were recorded based on their relevance for future eco-driver training, focusing on environmental performance and fuel consumption. Table 2 presents the parameters, their units, and a description.

Table 2. Variables Monitored and Calculated

Parameter	Denotation	Description
Drive Time (hh:mm)	Dv_Tm	Total time the vehicle is driven
Distance Driven (km)	Tl_Dst	Total distance travelled
Average Trip Distance (km)	Av_Dst	Average distanced travelled
Time over 110km/h (hh:mm)	Tm_Ov	Time travelled with speeds over 110km/hr
Acceleration Count	Accel	Number of times the vehicle performs a speed difference of ≥30km/h in ≤2.8 seconds
Deceleration Count	Decel	Number of times the vehicle performs a speed difference of ≥30km/h in ≤2.4 seconds
Idling	Idl	When the vehicle engine is turned on, but not moving (speed = 0 km/h)
Idling Time (hh:mm)	Idl_Tm	Total amount of time the vehicle is idling
Percentage of Idling Time (%)	Idl%	Percentage of time vehicle is idling
CO_2 Emissions from Idling (kg)	CO_2_Em	Kilograms of CO_2 emitted when the vehicle is idling[1]
Fuel Consumed from Idling (L)	Fuel_Idl	Litres of fuel consumed while the vehicle is idling[2]
Fuel Cost from Idling ($CAD)	Cost_Idl	Fuel consumed from idling[3]

[1] 2.289 kg/CO_2/L of gas and 2.663 kg/CO_2/L of diesel (Environment Canada, 2008).
[2] Idling time*fuel flow*60, with fuel flow = engine size* 0.6 (Environment Canada, 2008).
[3] Fuel consumed from idling*price of fuel (CAD$0.78/L, as per BMR onsite pricing).

The CarChips® were removed from each vehicle bi-weekly and the data was downloaded using a universal serial bus (USB) cable. The CarChip® memories were then cleared, reprogrammed and reinstalled into the corresponding vehicle to continue data logging. Data was recorded for the duration of the season, with the devices removed in April 2010. DriveRight Fleet Management Software Package was used in conjunction with Microsoft Excel, to view, analyze and calculate the data at varying degrees of detail.

Results

Management staff at BMR were provided with detailed summaries that outlined individual results for each of the 14 vehicles that participated in the study. Analysis included trip summaries (e.g., frequency and duration), driving summaries (e.g., duration, distance, speed, accelerations and deceleration counts), summary of the vehicle's fuel consumption and environmental performance (e.g., idling time, CO_2 emissions, fuel consumption, fuel costs from idling), and the comparative standing of each vehicle in relation to the other fleet vehicles at the resort. A detailed summary of daily trip information, in addition to a list of recommended behavioural changes to improve environmental and safety performance were also provided. Due to space limitations, an overview of the daily averages and totals for both individual vehicles and the summation of results for the entire resort fleet are provided in **Error! Reference source not found.**.

Across the recorded parameters it is evident that the range of variation among the vehicles is quite large, particularly with regard to those associated with trip and driving summaries. Within these parameters, total drive time per day varies between 17 minutes to over 11 hours, with total distance varying between 9 and over 240 kilometers per day and average trip distance between 2 and 27 kilometers. Much of this variation is due to the function that each fleet vehicle performs at the resort. For example, vehicle 10 is a public shuttle and is driven throughout the duration of operating hours, whereas vehicle 4 is utilized on an on-call basis when techsupport is required by resort staff. Moreover, speeds vary substantially across the sample of vehicles because some vehicles are required to stay on resort (maximum posted speed limits of 60km) compared to others that leave the resort and drive on highways (maximum posted speed limit between 80 and 100km).

However, variation amongst parameters that are of particular relevance for eco-driver training (speed, acceleration, deceleration, idling) are much smaller. It is among these parameters that it becomes increasingly clear that opportunities can be sought to introduce behavioural driving changes that can reduce fuel consumption and limit harmful idling emissions. Of the four vehicles driven off resort (vehicles 1-3, 14), more than 2 hours per day were driven at speeds equal to or greater than 110km per hour, decreasing fuel efficiency up to 23% (NRCan 2009a, West et al. 1999). Further opportunities to improve the economic and environmental performance across the fleet include reducing the number of daily hard accelerations (44.8) and hard decelerations (58.9), which uses approximately 33-40% more fuel than if the driver accelerated and decelerated gradually (Ericsson 2001, NRCan 2009a, Saboohi & Farzaneh 2009, Thew 2007). Idling is another driving behaviour that can be addressed as when the vehicles engines were turned on, they idled for more than 34% of the time. This leads to an average daily total of more than 135kg of CO_2 and consumes over 54L of fuel or approximately 24% of BMR total daily fuel consumption.

The average operating season for BMR is 100 days between the months of December and March, depending on weather. Based on the average daily totals, this equates to nearly 14 tons of CO_2 emissions and more than 5400L of fuel from idling in addition to the extra emissions and fuel consumed from speeding and hard acceleration/deceleration. When these numbers are extrapolated across the entire BMR ski fleet (55 vehicles), assuming average daily totals remained the same, idling alone emits in excess of 42 tons of CO_2, which is the equivalent of more than 16,000L of fuel priced at nearly $13,000.

Table 3. Daily Average and Daily Totals by Parameter

		Parameters										
		Dv_Tm	Tl_Dst	Av_Dst	Tm_Ov	Accel	Decel	Idl_Tm	Idl %	CO2_Em	Fuel_Idl	Cost_Idl
Vehicle	1	1:29	62	7	0:40	1.0	1.0	0:21	24	2.3	1.0	0.78
	2	1:18	61	8	0:38	2.5	1.4	0:14	19	1.8	0.8	0.62
	3	2:45	72	2	0:02	0.7	2.2	0:41	25	1.4	0.6	0.49
	4	0:17	9	2	0	2.0	0.6	0:04	23	0.3	0.1	0.11
	5	1:09	26	2	0	6.9	4.3	0:20	29	2.6	1.2	0.90
	6	2:56	38	2	0	6.9	3.1	1:27	50	10.8	4.7	3,69
	7	2:46	39	2	0	3.0	2.6	1:21	49	2.6	3.8	2.93
	8	3:31	29	2	0	0.6	1.0	2:18	65	15.8	6.9	5.37
	9	6:14	102	19	0	0.2	8.4	2:38	42	31.7	11.9	9.27
	10	11:37	248	27	0	0.6	4.6	2:54	25	15.3	5.7	4.47
	11	9:47	199	25	0	0.7	7.2	2:41	28	31.4	11.8	9.18
	12	2:41	38	3	0	9.5	11.7	1:13	45	7.2	3.1	2.44
	13	4:27	79	3	0	9.1	10.3	1:33	35	6.4	2.8	2.18
	14	0:31	21	4	1:27	1.0	0.6	0:05	17	0.2	0.1	0.06
Daily Avg		3:40	73	7.5	0:12	3.2	4.2	1:16	34	9.7	3.9	3.03
Daily Total		51:30	1022	-	2:48	45	59	18	-	136	55	42

Limitations and Moving Forward

There are two key limitations of the CarChip® as they are applied in this study. The first relates to idling. There are three circumstances in which individuals may idle their vehicle, including to warm the engine, waiting for something unrelated to traffic (e.g., a passenger), and while commuting (e.g., at a stop sign, traffic lights, railway crossing) (Carrico et al. 2009). This latter idling circumstance is difficult to avoid for functional and safety purposes and can therefore be deemed necessary idling and should not be included in the daily average and total idling time. Unfortunately the CarChip® quantified idling at every point when a vehicle was at zero kilometers per hour. In recognition of this limitation, phase three of this study (post-eco-driver training data collection) will collect second by second data and calculate those circumstances when the vehicle is idling for 60[4] seconds or less as necessary idling, thereby removing these circumstances from the daily averages and totals.

[4] Idling for 60 seconds or greater has been identified by NRCan as unnecessary idling (NRCan 2008).

The second limitation is the inability to calculate specific fuel consumption and CO_2 emissions for the parameters of speed, hard acceleration and hard deceleration. The CarChips® are not programmed to measure the exact degree of speeding, but rather to identify the duration of speeds over 110 kilometers per hour. Without such data, the precise decrease in fuel efficiency cannot be arrived at. This is similar for the acceleration and deceleration parameters, to which the CarChip® is unable to capture precise data on the speed and time difference at which the incident occurred. Although this data would be helpful, value remains in identifying the frequency of their occurrence as behavioural changes can target the reduction of these events.

The results of this study highlight the opportunities that are available to alter driving behaviour that is leading to thousands of kilograms of CO_2 emissions and consuming tens of thousands of dollars in unnecessary fuel consumption. Eco-driver training courses, based on the assessments and opportunities identified through this project, are being delivered to fleet drivers throughout autumn (November-December 2010). Results from this project are being incorporated into the courses, tailoring the curriculum to focus on those parameters where the drivers were the most inefficient. In order to assess the effectiveness of this training on driver behaviour, the next data collection phase will aim to install the CarChips® back into the same vehicles in preparation for the upcoming ski season (winter 2010-2011). Once the data is downloaded and analyzed, it is hoped that the eco-driver training will reveal an improvement in the environmental and economic performance at BMR.

Final Thoughts

While increased attention and concern for sustainable tourism may be the direction of the future, it does not ensure its implementation or success. It is of crucial importance for developers, planners and regulators of tourist destinations that the right tool be selected. This tool must both define the areas where corrective actions are necessary, as well as measure whether the desired amendment of the situation was achieved (Schianetz et al. 2007, Butler 1999). This paper demonstrates the value of in-vehicle monitoring technology as a tool to identify opportunities to improve the sustainability of a ski resort fleet through the adoption of eco-driver training. With tourism facing its greatest challenge to date, climate change, world tourism leaders and organizations are urgently calling for the reduction of climate altering emissions within the sector (UNWTO et al. 2008). Best practices from this project can be used as a model for additional snow resorts with the aim of reducing the industry's CO_2 emissions, while also holding promise for other nations and types of tourism destinations.

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