

# The Effectiveness of Ecodriving Program in the Real-world Driving

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In this study, we investigated the effectiveness of the Ecodriving program in the real-world by monitoring fuel consumption before and after the Ecodriving program. According to the results, four out of the nineteen drivers practiced idling stop, while seven conducted gentle start. We also found that female drivers practiced idling stop, while male drivers practiced gentle start more. The relationship between the fuel economy during the Ecodriving training program and that in the real-world was not so clear.

**Key Words :** *Ecodriving, fuel economy, idling stop, gentle start*

## 1. INTRODUCTION

Global economic growth and urban sprawl often leads to increase in motorization. This in turn translates to increased transportation demand and increased movement of travel distance which further increased the on-road CO<sub>2</sub> emission load and fuel consumption. Consequently, the International Energy Agency (IEA) report in 2004 claims that major source of CO<sub>2</sub> emissions comes from the transport sector. In particular, the rising motorization in developed and developing countries created environmental and transport issues such as traffic congestion, vehicular pollution, car dependency, ageing vehicle, increasing fuel cost etc., have greatly challenged transportation policies.

Today, much attention is focused on the reduction of fuel consumption of road transport, because of the depleting reserves of fossil fuels and the concern on global warming and climate change due to increasing CO<sub>2</sub> emissions. Some developed and developing countries have made future plans for reducing CO<sub>2</sub> emissions from transportation<sup>1)</sup>. While the introduction of hybrid and electric cars and provision of less carbon-intensive public transportation are common policy measures in these plans, the measures for improving fuel economy by reducing traffic conges-

tion and promoting an efficient driving style are also suggested because the penetration of new cars takes time and the provision of public transportation might not be so effective in small or medium-sized cities<sup>2)3)</sup>. Thus, since sustainable mobility means mobility with low CO<sub>2</sub> emissions and CO<sub>2</sub> emissions of a vehicle is proportional to its fuel consumption, low CO<sub>2</sub> emissions also means low fuel consumption. One of the approaches to attain sustainable mobility is Ecodriving.

Ecodriving is primarily a driving technique designed to improve fuel economy, reduce CO<sub>2</sub> emissions and mitigate the adverse impacts of road transport on its surrounding environment<sup>4)</sup>. It is the attitude of driving in an environmentally-conscious and energy-efficient manner. In general, Ecodriving programs are directed to change a driver's driving attitude through a generally improved driving operation and practice of practical driving advisory. The basic operational technique characterizing Ecodriving includes: efficient speed application (starting, acceleration, and cruising), switching-off the engine (e.g., during signal stop, parking etc.), appropriate choice of gear (manual transmission), appropriate control on acceleration and deceleration, and efficient coasting or gliding, anticipation of traffic condition. Along with these characteristics,

practical advisories are also recommended which include: regular vehicle maintenance (e.g. engine, tyres, air conditioner, etc.), minimizing mass and improving aerodynamics anticipating traffic flow and signals, avoiding sudden starts and stops, driving at or below the speed limit, maintaining an even driving pace, appropriate choice of fuel type (i.e. octane level) and engine oil, wise usage of in-vehicle electronics (i.e., stereo, air conditioner, etc.), and employment of on-board computers and navigational systems (e.g., cruise control, GPS, trip computers, revolution counter, etc.). In the real-world application of Ecodriving, on-road fuel consumption and emission values are influenced by drivers driving style which are in turn directly influenced by external factors such as: traffic characteristics, road characteristics, vehicle characteristics, cultural or inherent driver's characteristics, trip characteristics and other variables. The application of Ecodriving is particularly effective for intra-urban car trips because of several signals and other stop-and-go occasions in urban areas<sup>5)</sup>.

This study aims to investigate the effectiveness of Ecodriving program especially in the real-world by assessing the driving data obtained from the real-world driving before and after the Ecodriving program.

## 2. REVIEW OF PRECEDING STUDIES

Ecodriving program depends on the external factors which include: vehicle, driver, road, traffic and trip characteristics. While past studies focused on the whole or a part (such as idling stop) of the content of Ecodriving program<sup>6)7)</sup>, and on the relevant equipment for helping drivers to adapt themselves to Ecodriving styles<sup>8)</sup>, recent studies focused much attention to the effectiveness of Ecodriving in urban areas where traffic congestion prevailed and Ecodriving styles might not always be applicable within dynamic traffic conditions<sup>9)10)11)</sup>. The effect of the professional driver's characteristics including psychological aspects on the outcome of Ecodriving program was also investigated<sup>12)</sup>.

The results of the studies on the effectiveness of Ecodriving program differ from one study to the other. Ukita and Shirota<sup>13)</sup> study revealed that advisory on reduced car loading (i.e. passengers, luggage etc.) resulted to 15% fuel savings and 3.5% reduction of CO<sub>2</sub> emissions. While, Ecodriving program such as those in Europe that target on improved driving operation revealed the fuel consumption values up to 10% - 20%<sup>14)</sup>. Similarly, programs such as those in

Japan on Smart Ecodrive contest that compared fuel consumption savings between normal driving and Ecodriving attained as much as 25%<sup>4)</sup>. Even real-time driving comparison on a controlled course after training drivers with Ecodrive driving style resulted to improved fuel savings and reduced CO<sub>2</sub>. Katayama and Taniguchi<sup>15)</sup> suggested that this success depends on the driving lecture on Ecodrive and skill-transfer of the driving technique.

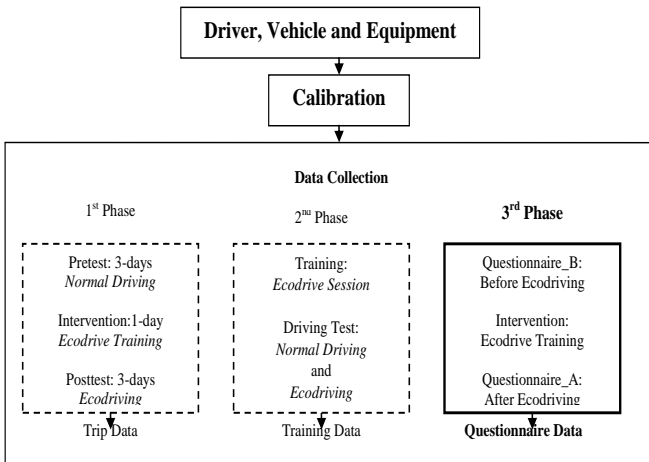
While past studies investigated the effectiveness of Ecodriving program by comparing fuel consumption before and after the program participation, most of them obtained data from the driving on the pre-determined test courses or the artificial environment created by driving simulators. Because the driver who participates in Ecodriving program and who performs well in the program is not always assumed to drive in the same Ecodriving style when he drives his own car in the real-world after the program. Therefore, if we are to know the effectiveness of Ecodriving program, we need to compare fuel consumption before and after the Ecodriving program in the real-world.

Considering the above preceding studies, we studied fuel consumption and the effectiveness of Ecodriving programs in developing (Manila) and developed (Tokyo) countries. In this paper, we focused on the driver's real-world driving data obtained from Tokyo case before and after the Ecodriving program. Alongside this, an interim evaluation on the program day results was also assessed. In the next chapter, we discussed the outline of our study methods including the design of the Ecodriving program and equipments, data collection and the characteristic of the data obtained. In chapter four, we presented the results of the real-world driving performance before and after the Ecodriving program. In chapter five, we indicated our conclusions and discussed the directions of future researches.

## 3. METHODOLOGY

Two sets of drivers' group were considered for data collection, namely, the group from Japan and the Philippines, particularly in the capital cities of Tokyo and Manila. As a requirement, private car drivers who were willing to participate in the Ecodriving program should own gasoline-fueled Japanese car (Model Year 2000-2010) with compatible On-Board Diagnostic (OBD) for the monitoring equipment. The cars were calibrated and tested for the Global Positioning System (GPS) and a

Fuelmeter gadget. Both equipments collected instantaneous data per 0.10 second.



**Fig. 1** Data Collection Process

Data collection process as shown in **Fig. 1** was divided into three separate phases, namely: data from driver’s trips (in the real-world), data from driver’s questionnaires and data from Ecodriving program of drivers. First, for the driver’s trip data, the data collected were from the three days pretest or normal driving dataset (prior to the Ecodriving training day) and another three days for posttest or Ecodriving dataset in the real-world. For collecting the driver’s trip data, each driver used his or her own car and route freely. Second, for the Eodriving program training data, on the training day, drivers underwent Ecodriving orientation, driving test and evaluation by qualified instructors.

During the training, the same car type (a compact car) and the same test route were used for all the participants in Tokyo respectively on each weekend training day (i.e. Saturdays) where the volume was relatively low. The drivers were subjected to two rounds of driving tests. The first test driving was conducted under the condition of normal (non-ecodriving) driving, while the second test driving was under the condition of Ecodriving (i.e. after the practical instructions). Diagnostic evaluation, consultation and advisory of each driver proceeded after the driving test.

Finally, for driver’s questionnaire data, to test the effect of Ecodriving training on drivers driving characteristics, a pretest-posttest questionnaire was given to the drivers. The pretest questionnaires were administered before the Ecodriving training while the posttest questionnaires were administered on the last day of trip data collection.

The analysis of this study will be limited to the analysis of the driver’s trip data in the real-world and

the training data during the program. The results will be compared to assess the change in driving performance such as fuel consumption before and after the program training.

#### 4. THE EFFECTIVENESS OF THE ECODRIVING PROGRAM

In order to collect fuel consumption (FC) data and Global Positioning System(GPS) data, we asked 27 drivers to take the Ecodriving training program and equipped their cars with the calibrated GPS and FC gadgets before and after the Ecodriving program. We especially focused on the efficient speed application or ‘gentle start’, and switching-off the engine or ‘idling stop’ (e.g., during signal stop, parking etc.) because the operational techniques are intensively taught in the Ecodriving program and are supposed to contribute to reducing fuel consumptions considerably. Out of the 27 drivers, we were successful in obtaining nineteen driver’s datasets which enabled us to compare the driving performance before and after the program sufficiently.

By indicating GPS data on GIS road network map and by matching the location with fuel consumption data, we built the dataset containing the information on fuel consumption during stopping and acceleration after the stopping, stopping time mostly due to intersection signals, and acceleration pattern after the stopping for each driver. The data on the stopping is used for investigating the practice of idling stop, while the data on the acceleration is used for studying the practice of gentle start.

The result of the analysis on the effectiveness of the Ecodriving program is shown in **Table 1**. In terms of idling stop, after the Ecodriving program, four out of the nineteen drivers demonstrated reduction in fuel consumption significantly with 5 percent of significance in the real-world. However, there were two drivers whose performance worsened after the program. In term of gentle start, seven drivers indicated reduction in fuel consumption significantly. Most drivers were successful in reducing fuel consumption after the program in terms of idling stop and gentle start occasions, however, the differences were mostly not statistically significant.

**Table 1.** The Effectiveness of the Ecodriving Program (the number of drivers)

5% Significance	Idling Stop	Gentle Start
Improved	4	7
Worsened	2	0
Unchanged	13	12

Next, we classified the drivers into the group with large difference, medium difference and small difference according to the difference (improvement) of fuel consumption before and after the program. Each group consists of six to eight drivers. Firstly, in the analysis of idling stop, the group with large difference tended to include many female drivers and the group with small difference tended to include many male drivers. In the analysis of gentle start, the tendency was the reverse. Therefore we suppose that female drivers practice idling stop, while male drivers practice gentle start more easily.

Second, we studied the relationship between the fuel economy improvement during the Ecodriving training program and the three groups. In the analysis of idling stop, the group with small difference indicated the largest improvement, while in the analysis of gentle start, the group of medium difference the largest. Therefore, the result of the Ecodriving program is not necessarily related with the real-world practice of Ecodriving.

## 5. CONCLUSIONS AND FURTHER STUDIES

In this study, we investigated the effectiveness of the Ecodriving program in the real-world by monitoring fuel consumption before and after the Ecodriving program. According to the results, four out of the nineteen drivers practiced idling stop, while seven conducted gentle start. We also found that female drivers practiced idling stop, while male drivers practiced gentle start more. The relationship between the fuel economy during the Ecodriving training program and that in the real-world was not so clear.

For further studies, first, we need to investigate the relationship between the real-world fuel economy and the driver's characteristics, which might improve the way of the Ecodriving program. Second, we also need to compare the results from Tokyo case in this paper with the results from Manila case because the conditions in Manila are very different.

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