Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 136 (2017) 438–443

Energy Procedia

www.elsevier.com/locate/procedia

4th International Conference on Energy and Environment Research, ICEER 2017, 17-20 July 2017, Porto, Portugal

CO_2 emission of tourist transportation in Suan Phueng Mountain, Thailand

Angsumalin Jamnongchob[a], Orawan Duangphakdee[b], Phongthep Hanpattanakit[a] *

[a]*Faculty of Environmental Culture and Ecotourism, Srinakharinwirot University, 114 Sukhumvit 23 Bangkok, 10110, Thailand*
[b]*King Mongkut's University of Technology Thonburi (Ratchaburi Campus), Bangkok 10140, Thailand*

Abstract

Transportation represents the key contributor to greenhouse gas emissions, which are linked to global warming and climate change. The objective of this study was to estimate the amount of CO_2 emission from energy consumption by tourist transportation in Suan Phueng, Thailand. The methodology of a bottom up approach was observed by using questionnaire surveys. First, the questionnaire design can be validated by calculating the Item-Objective Congruence (IOC) index as 0.96, which was acceptable. Moreover, CO_2 emission from energy consumption by transportation was calculated following IPCC2006 guideline. Then, the 400 questionnaires were distributed to the tourists. The results estimated the average distances as 208.15 ± 139.38 km. Total energy consumption of gasoline and diesel in transportation were 4,810.85 and 8,640.91 liters. Car was the most popular vehicle for visiting this area about 78%, respectively. Total and mean CO_2 emissions in tourist transportation were 32,249.66 kg CO_2 eq and 21.20 kg CO_2 person^{-1}.

Peer-review under responsibility of the scientific committee of the 4th International Conference on Energy and Environment Research.

Keywords: CO_2 emission; tourist transportation; suan phueng mountain

1. Introduction

Global warming is often expressed as a significant change in average surface temperatures, resulting from

* Corresponding author. Tel.: +6686-415-2906; fax: +662-260-3275.
E-mail address: phongthep@g.swu.ac.th, hanpattanakti@gmail.com

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 4th International Conference on Energy and Environment Research.
10.1016/j.egypro.2017.10.300

changes in the planetary radiative balance, and determined by the concentration of greenhouse gases (GHG) in the atmosphere. Carbon dioxide (CO_2) is the most important greenhouse gas, accounting for 78% of the global anthropogenic emission (32.3 Gt) in 2011 [1]. In fact, recent data reveals that global CO_2 emissions were 150 times higher in 2011 (198 $MtCO_2$) than they were in 1850 (32,274 $MtCO_2$). Asia's gross domestic product became the largest in the world for 1994. Interestingly, though, Asia became the largest emitter of CO_2 due to rapid economic growth. In the past, the largest share of global emissions came from Europe and Northern America. But by the end of 2011, Asia dominated, contributing more than half of global CO_2 emissions, which are linked to global warming and climate change [1]. The GHG emission intensity per capita in Thailand for 2011 was the third GHG emission in Asia as highly emits about 103 tCO_2 eq/USD 100,000 [2]. The second Thailand's inventory in 2000 of anthropogenic GHG emission was about 229.08 $TgCO_{2eq}$. The energy sector is the largest contributor of greenhouse gas emissions equivalent to 159.39 $TgCO_{2eq}$, and share 69.6 percent of the total national emission. The energy consumption in transportation is the key major source of GHG emission in Thailand [3]. According to Energy Forecast and Information Technology Center, Energy Policy and Planning Office addressed the significant CO_2 emissions of 63.15 million tons generated by fuel consumption in which the transportation and traffic sector was responsible for the release of approximately 27% of GHG emissions from commercial energy consumption, such emissions area consequence of the driving force of transportation services in Thailand's economic and social development together with the continued growth of energy use in the sector [4]. Moreover to the a fore mentioned problems, Thailand continues to face the environmental impacts caused by the use of transportation fuels, especially GHG emissions and air pollutants, such as carbon monoxide (CO), hydrocarbon (HC), nitrogen oxide (NO_X), particulate matter (PM), sulfur dioxide (SO_2), etc. Such pollutants are proven to be directly harmful to human health and are considered as a major cause of the urban climate deterioration that is affecting people [5]. Beyond the health impact regarded as a direct effect, transportation related air pollution primarily causes greenhouse phenomena resulting from CO_2. The occurrence of such phenomena leads to changes in ecosystems, such as marine ecosystem transformation due to the increase in temperature that tremendously affect aquatic animal adaptations, thereby increasing the death rate. Hence, the scientist found the good practice for reducing impact of the environment from energy consumption in transportation sector.

The trends of tourism industries in Thailand were very fast increasing growth in the past decade. Estimates of tourism receipts directly contributing to the Thai GDP of 12 trillion baht range from 9 percent (1 trillion baht in 2013) to 17.7 percent (2.5 trillion baht) in 2015 [6]. The GHG emission of the tourism industry was produced from multiple perspectives, including transportation, sightseeing, accommodation and food, shopping, entertainment, post and telecommunication, etc. Meng et al. (2016) study the quantifying direct and indirect carbon dioxide emissions of the Chinese tourism industry. They found that carbon emissions were estimated to contribute 1.059% to the national CO_{2eq} in 2010. From a sector perspective, transportation accounted for two-thirds of the tourism carbon emissions, followed by accommodation and food services (12.45%) and shopping (12.10%). For urban area uses 84% of China's commercial energy. The 35 largest cities, containing 18% of the total population, contribute 40% of national energy uses and CO_2 emissions [7]. In 2009, the World Travel Tourism Council sets the goal of cutting the carbon emission of the tourism industry by 25-30% in 2020 and 50% in 2035 compared to the baseline of 2005 [8]. However, the energy consumption and CO_2 emission of the tourism industry in Thailand is very limited, because it is not separate energy consumption followed by the traditional part of the national economy account system. However, the CO_2 emission of the tourism activities in Thailand is sorely lacking available calculation, but it is very important for energy conservation and CO_2 emission reductions. Therefore, the purpose of this study is to propose a technique predicting the amount of CO_2 emissions by bottom up technique and GHG mitigation options of tourist transportation in Suan Phueng Mountain, Thailand.

2. Material and method

2.1. Questionnaire design

Questionnaire was used as the tools to collect data about CO_2 emission and reduction in tourist transportation in Suan Phueng, Thailand. To ensure the validity of the questionnaire by calculating the Item-Objective Congruence (IOC) index, the test was given to five experts to examine and rate each item so that the content met the objectives of the study. The IOC was calculated by assigning scores to three types of answers: congruent = 1, uncertain = 0, incongruent = -1. The result of IOC is 0.96, which is acceptable.

400 samples were selected by accidental sampling from the visitors in Suan Phung, Thailand during September 2006 - March 2017 [9]. Data were analysed by using statistical computer program and interpreted by section as follows:

Section 1: Personal information were analysed in terms of frequency and percentage.

Section 2: The attractions image perception of Suan Phung's visitor were analysed in terms of percentage and mean.

Section 3: CO_2 emission evaluation in transport sector at Suan Phung, Thailand was analysed to energy consumption and GHG emission.

2.2. CO_2 emission from transportation

A calculation of air pollutant emissions involves the estimation of the amount of CO_2 released from energy used in tourist transportation during the distance between home and Suan Phung Mountain location. The Energy Policy and Planning Office (2012) calculated the CO_2 emissions from energy consumption and the emission factors of fossil fuel types via referencing the method of estimation and emission factors following the 2006 Intergovernmental Panel on Climate Change (IPCC) criteria. The formula is as follows:

$$CO_2\ emission = \Sigma\ (EF_{Fuel} \times FC_{Fuel}) \quad (1)$$

where CO_2 emission is the amount of CO_2 released from energy consumption, emission factor of fuel (EF_{Fuel}) is the CO_2 emission factor by fossil fuel types (based on the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories). The EF_{Fuel} of gasoline and diesel fuels for transportation were 2.1896 and 2.7446 kg $CO_{2eq}liter^{-1}$, respectively. In addition, fuel consumption (FC_{Fuel}) was calculated by multiple by the distance and fuel consumption rate separated by the vehicle types (Table 1).

Table 1. Fuel consumption rate separate by vehicle type.

Vehicle type	**Fuel type**	**Fuel consumption rate (km/L)**	**References**
1. Small car (1,500 cc)	Gasoline	17.770	Pollution Control Department, 2012
2. Medium car type 1 (1,600 cc)	Gasoline	15.238	Pollution Control Department, 2012
3. Medium car type 2 (1,800 cc)	Gasoline	13.796	Pollution Control Department, 2012
4. Big car (≥2,000 cc)	Gasoline	12.248	Pollution Control Department, 2012
5. Average truck	Diesel	6.369	American Petroleum Institute, 2016
6. Van	Diesel	10.204	American Petroleum Institute, 2016
7. Bus	Diesel	2.850	American Petroleum Institute, 2016
8. Motor bike	Gasoline	36.625	Pollution Control Department, 2012
9. Big bike	Gasoline	38.655	Pollution Control Department, 2012

3. Results and discussion

3.1. Demographic information

Table 2 shows the demographic information of tourist in Suan Phung Mountain, Ratchaburi province, western Thailand. The result found that the ratios of female and male were 54.4 and 45.6%, respectively. The age frequencies of the tourists were 21-30 and 30-40 years old as about 70%. The tourist age referred to the people was in working age. The result found that 83.75% of the tourists had working in government and non-government officer and 16% were students. Moreover, the most of the tourist education level was graduated in bachelor degree. In addition, the attractions image perceptions of Suan Phung's visitors were as follows: 65.5% of visitors were repeat visitors, and 71% of visitors visited Suan Phung Mountain around 1-5 times. About 87.75% of the visitor purposes were mainly leisure.

Table 2. Frequency and percentage of visitors's personal information..

Personal information of visitors	Frequency N = 400	Percentage	Personal information of sample	Frequency N = 400	Percent
GenderMale	174	43.6	**Occupation:**Government officer	20	5.0
Female	226	56.5	State Enterprise Employee	92	23.0
Age Below 21 years	35	8.75	Business owner	59	14.75
21-30 years	144	36.0	Self-employed	14	3.5
31-40 years	128	32.0	Private organization employee	135	33.75
41-50 years	64	16	Student	64	16.0
51-60 years	18	4.5	Others	15	3.75
More than 60	11	2.75	N/A	1	0.25
Education Elementary school	10	2.5			
High school	60	15.0			
Certificated or similar	25	6.25			
Bachelor degree	223	55.75			
Higher Bachelor degree	80	20.0			
Others	2	0.5			

3.2. Attractions image perception

Suan Phung Mountain located on high ground and surrounded by mountains closing to the border of Thailand and Myanmar. The 160 km distance between Bangkok and Suan Phung Mountain - takes a drive less than 2 hours, and is also a very popular weekend destination. Besides a handful of themed destination resorts with white washed Mediterranean villas and sheep farms, Suan Phueng has a few but interesting natural attractions. Pong Yoop curious geological formations caused by sudden collapse of soil thousands of years ago, is a quick stop. Not far from Pong Yoop is Bo Kleung Hot Spring (15 km north of Suan Phueng) where you can have a dip in a well-landscaped pool and enjoy the picturesque scenery. Kao Jone Waterfalls, slightly north of Bo Klueng, is ideal for hiking. The 2.5 km trail, crisscrossing a dense, forested jungle and coving nine levels, takes about two-and-a-half hours to complete.

Suan Phung's impression can be categorized into 13 impression as follows; Climate (79.0%, mean = 3.95), Landscape and scenery (81.1%, mean = 4.06), Natural attraction (81.3%, mean = 4.07), Historical attraction (65.2%, mean = 3.26), Relaxing atmosphere (81.5%, mean = 4.08), Local culture (72.0%, mean = 3.60), Courtesy of local people (77.9%, mean = 3.89), Local food and souvenir (77.6%, mean = 3.88), Accommodation, restaurant and shop (79.6%, mean = 3.98), infrastructure (75.5%, mean = 3.78), Superstructure (70.6%, mean = 3.53), Car rental public transportation and travel operation (66.2%, mean = 3.31) and Information service (72.1%, mean = 3.61) as shown by the results in Table 1.

Table 3. Percentage and mean of Suan Phung's impression..

SuanPhung's impression	Percentage	$\bar{x}$	SuanPhung's impression	Percentage	$\bar{x}$
Climate	79.0	3.95	Local food and souvenir	77.6	3.88
Landscape and scenery	81.1	4.06	Accommodation, restaurant & shop	79.6	3.98
Natural attraction	81.3	4.07	infrastructure	75.5	3.78
Historical attraction	65.2	3.26	Superstructure	70.6	3.53
Relaxing atmosphere	81.5	4.08	Car rental, public transportation & travel operation	66.2	3.31
Local culture	72.0	3.60			
Courtesy of local people	77.9	3.89	Information service	72.1	3.61

3.3. CO_2 emission and mitigation option in transport sector

The average distances of tourists between home and Suan Phung Mountain location was 208.15 ± 139.38km. Total energy consumption of gasoline and diesel in transport sector of 400 tourists were 4,810.85 and 8,640.91 liters. Car was the most popular vehicle for visiting this area about 78% (Fig. 1). Cars were occupied of Thai's more than previous times because Thai government's promotes economic policy by reducing the tax when they bought the first car for 2011. Moreover, total CO_2 emissions in transportation sector separated by the fuel consumption as gasoline and diesel were 10,533.83 and 23,715.83 kg CO_{2eq}, respectively (Table 4). The average CO_2 emission was 21.20 kg CO_2 $person^{-1}$.

Normally, the GHG emission in tourist activity was produced from transportation sector, according to previous research shown that GHG emission in transportation of Chinese tourism industry was the highest contributor about 48.25% [8]. The carbon emissions ratio of transportation was higher than the other activities. So the policies should be made concerning this transportation activity, for example more stringent vehicle fuel standards should be developed; energy saving cars and electric vehicles should be encouraged, and at the same time, public transportation should be developed greatly [8]. Moreover, the mitigation options of tourist transportation in Suan Phueng, Thailand were bicycling because the distance between each landmark were quite short and also had the scenic road. Thus, tourism authority of Thailand and Suan Phueng entrepreneur did the good biking trails around Suan Phueng Mountain. The five biking trails were King of Mountain (50 km), Karen Villages (17 km), Tree Tunnel (30 km), Sunset Route (32 km), and Hang of Hills (33 km). Therefore, they should be ride the bicycle for sightseeing this scenic area, which will be reducing the CO_2 emission from tourist transportation about 20 percent of total emission. In addition, the eco-friendly energy use should be advocated. Biofuel is recognized as an environmentally friendly and renewable source. It is predicted that around 27% of the transportation fuel would be replaced by biofuel by 2050 in South East Asia [10]. According to Thai government has approved the exemption of excise tax imposed on ethanol, controlling the retail price of gasohol (a mixture of ethanol and gasoline at 10% (E10) and 20% (E20) to be less than that octane 95 gasoline, within a range not exceeding 8-10 baht a liter (Exchange rate 33 baht/ US dollar). The policy promoting ethanol for transportation is being supported by its positive effects on energy security and climate change mitigation in the country. Thus, the raw material to make ethanol was highly potential in Thailand such as more crop residual in agriculture. Nguyen et al. (2007) analysis of energy and greenhouse gas balances was done to evaluate fuel ethanol produced from cassava in Thailand. The results found that positive energy balance of 22.4 MJ/L and the net avoided GHG emission of 1.6 kg CO_{2eq}/L found for cassava-based ethanol. Although, the trend of energy uses in transportation has a relatively fast growth, and affect to the increasing of the GHG emission. Therefore, we need to establish a system that promotes low carbon tourism consumption and reduce the energy use intensity, so as to realize the win-win situation of tourism activity development and reduction of GHG emission in Thailand.

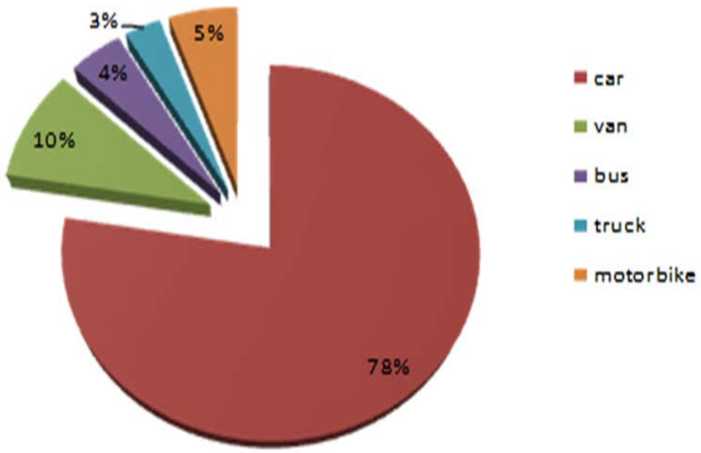

Fig. 1. Proportion vehicle types of travelling at Suan Phung mountain.

Table 4. The energy consumption and CO_2 emission from transportation at Suan Phung mountain.

Type of fuel	Total energy consumption (Liter)	Average energy consumption (Liter/person)	Total CO_2 emission (kg $CO_{2\,eq}$)	Total CO_2 emission (kg $CO_{2\,eq}$/person)
Gasoline	4,810.85	8.41	10,533.83	18.42
Diesel	8,640.91	10.55	23,715.83	28.96

4. Conclusion

The fuel consumption of transportation is the key contributor to GHG emission from the tourism industry. The methodology for estimate the GHG emission in tourism activity in Thailand is very limitation but it is very important to evaluate and mitigate GHG emission in national GHG inventory. The research shown that the carbon emission from transportation was calculated follow by bottom up method in case study at Suan Phung Mountain, Ratchaburi, Thailand. Total CO_2 emissions in transportation sector separated by fuel consumption as gasoline and diesel were 10,533.83 and 23,715.83 kg CO_2eq. The average CO_2 emission was 21.20 kg CO_2 person^{-1}. In addition, the mitigation options in Suan Phung mountain transportation were suggested that to change tourist behaviors such as used bicycling and eco-friendly energy.

Acknowledgements

This research was supported by funding research works and presentation budged from Faculty of Environmental Culture and Ecotourism, Srinakharinwirot University (No. 084/2559).

References

[1] World Resources Institute (WRI). The top 10 emitting countries still make up 78 percent of global CO_2 emissions. Hist. carbon dioxide emission 2012. http://www.wri.org/blog/2014/05/history-carbon-dioxide-emissions.
[2] The 11th Malaysia Plan. Pursuing Green Growth for sustainability and resilience 2015. http://rmk11.epu.gov.my/book/eng/chapter-6/Chapter%206.pdf.
[3] The office of traffic and transport policy and planning. The study to develop master plan for sustainable transport system and mitigation of climate change impacts, Bangkok, Thailand; 2012.
[4] Office of transport and traffic policy and planning. Air pollution from the transport sector; 2013.
[5] Ratanavaraha V, Jomnonkwao S. Trends in Thailand CO_2 emissions in the transportation sector and policy mitigation. J Trans Poli 2015; 41:136-146.
[6] Turner R. Travel and tourism, economic impact, Thailand. London: World travel and tourism council; 2015.
[7] Dhakal S. Urban energy use and carbon emissions from cities in China and policy implications. Energy Policy 2009;37:4208-4219.
[8] Meng W, Xu L, Hu B, Zhou J, Wang Z. Quantifying direct and indirect carbon dioxide emissions of the Chinese tourism industry. J Clean. Produc 2016; 126:586-594.
[9] Yamane T. Statistics: An Introductory Analysis, 2nd ed. New York: Harper and Row; 1967.
[10] International Energy Agency (IEA). South-east Asia energy outlook, world energy outlook special report. Paris, France; 2013.
[11] Nguyen TLT, Gheewala SH, Garivait S. Energy balance and GHG-abatement cost of cassava utilization for fuel ethanol in Thailand. Energy Policy 2007;4585-4596.
[12] Pollution Control Department, Performance Report of the Fiscal Year Vehicle Pollution Laboratory during 2008-2011 2012. http://www.pcd.go.th/info_serv/air_diesel_autolab.html.
[13] American Petroleum Institute, Free Petro Calculator Program 2017. http://www.petrospection.com.au/petrocalculator.htm.