Case Studies on Transport Policy 3 (2015) 468–476

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

Energy-saving potential analysis and assessment on land transport of Taiwan

Shyi-Min Lu*

Retiree of Energy and Environmental Laboratories, Industrial Technology Research Institute, Building 64, No. 195, Sec. 4, Chung Hsing Rd., Chutung, Hsinchu 31040, Taiwan, ROC

ARTICLE INFO

Article history:
Received 8 February 2014
Received in revised form 24 October 2015
Accepted 6 November 2015
Available online 11 November 2015

Keywords:
Land transport
Energy use
Energy intensity
Energy-saving strategy

ABSTRACT

Among the various research institutes in Taiwan, the overall transportation energy consumptions and energy saving statistics are quite in the lack. This study first of all collects the transportation data from Statistics Department and Institute of Transportation of the Ministry of Transportation and Communications for the purpose of application research. Meanwhile, energy consumption factors are retrieved from the Bureau of Energy, Ministry of Economy and relevant papers; thereby, the energy consumptions of passenger and freight vehicles are analyzed statistically. Furthermore, the total energy consumption of current transportation is calculated. The calculation results show that the transportation capacity and energy intensity of passenger cars are the largest ones in the all land vehicles. Therefore, the passenger cars have the greatest potential for energy saving. Finally, this study sums up the implementation of energy-saving strategies, including the application of BAT (Best Available Technologies) and the augment of public transportation infrastructure. Through scenario analysis, the results of this study show that the national GHG abatement goal in 2025 (i.e., 5.2 Mt-CO_{2e}) is fulfilled. Wherein, the energy-saving is 2931 MKLOE with reduction rate of 27%, or 2.43% in national scale, while the equivalence of GHG abatement is 5.91 Mt-CO_{2e}, or 2.40% in national scale.

1. Foreword

Transportation is the indispensable tools and conditions in modern daily life and economic activity. As Taiwan's economic growth and population mobility, transport demand increases day by day, making the transport sector's energy consumption have also come to rise, and the significant increases of GHG emissions and the amount of air pollution. For example, in 1990, 2000 and 2010, the yearly rising energy consumptions by the transport sector are respectively 7958, 14,316 and 15,546 KLOEs (MOEABOE, 2012a). The average annual growth rate of 3.3% is the second highest in the all sectors of final energy consumption besides industrial sector. The fuel consumption rate clearly shows a substantial growth of energy consumption in transport sector. However, it also means that this sector did not fully implement the policies and measures of energy conservation.

In the transport sector, road transport accounted for the largest portion of energy consumption. As in 2010, for example, the energy consumed by the transport sector in Taiwan was about 15,546.3 KLOEs (thousand kiloliters of oil equivalent), of which road transport alone is 12,643.9 KLOEs. In other words, Taiwan's land transport consumes about 81% of the all fuel used in transport sector (MOEABOE, 2012a), while the majority of energy sources consumed by land transport belongs to fossil fuels, compared to the rail transport based on electricity, we found that carbon dioxide emissions from current road transport is amazing.

According to the statistics of International Energy Agency (IEA, 2012) and the Bureau of Energy, Ministry of Economic Affairs (MOEABOE, 2012b), the transport sector is the main sources of energy consumption and greenhouse gas emissions for the countries in the world and Taiwan. To reduce greenhouse gas emissions and save energy, the transport sector is a very important block that is needed to be discussed and analyzed in depth.

This study is to investigate the Taiwan's transportation sector as the main object, which contains a variety of main means of transportation, for example, cars, motorcycles, buses, trucks, MRT (Metro Rail Transit), TRA (Taiwan Railways Administration), high-speed rail and other transport modes. According to the transport report issued by Taiwan's Ministry of Transportation and Communication and the Energy Statistical Yearbook published by Bureau of Energy of Ministry of Economic Affairs, this study

* Correspondence to: 11F-1, No. 58, Section 5, Nanking East Road, Taipei 105, Taiwan, ROC.
E-mail address: shyimin@gmail.com (S.-M. Lu).

http://dx.doi.org/10.1016/j.cstp.2015.11.003
2213-624X/

estimates the mileage, load capacity, and energy consumption in the all land transportation of Taiwan.

Transportation is the lifeblood for sustaining a nation's economy. In recent years, since of the gradual depletion of fossil fuels and emerging seriousness of global warming, this article aims to plan our national future green transportation development blueprint through the optimization of energy-saving and carbon-reducing measures. Meanwhile, this study is to analyze and assess the energy-saving potential of Taiwan's land transportation through the application of scenario analysis. Wherein, the pursuit goal – "The CO_2 emissions in 2025 should be reduced to that of 2000" – is based on the national energy's policy released by Executive Yuan in 2009; namely, "Sustainable Energy Policy Guideline". The energy-saving mechanisms and measures adopted in this study are Best Available Technologies (BAT) for land transport vehicles and the expansion of public transportation infrastructure.

2. Literature reviews

In 2007, Lu et al. adopted the Divisia index approach to explore the impacts of five factors on the total carbon dioxide emissions from highway vehicles in Germany, Japan, South Korea and Taiwan during 1990–2002. CO_2 emission was decomposed into emission coefficient, vehicle fuel intensity, vehicle ownership, population intensity and economic growth. The decoupling effects among economic growth, transport energy demand and CO_2 emission were analyzed to better understand the fuel performance and CO_2 mitigation strategies for each country. From the results, Lu et al. (2007) suggest that the rapid growths of economy and vehicle ownership were the most important factors for the increased CO_2 emissions, whereas population intensity contributed significantly to emission decrease. Energy conservation performance and CO_2 mitigation in each country are strongly correlated with environmental pressure and economic driving force, except for Germany in 1993 and Taiwan during 1992–1996. To decouple the economic growth and environmental pressure, proponents of sustainable transport policy in Taiwan should focus on improving the operation and energy use of its highway transportation system by implementing an intelligent transportation system (ITS) with demand management, constructing an integrated feeder system, and encouraging the use of green transport modes.

In 2009, a gray forecasting model GM(1,1) was adopted by Lu et al. to capture the development trends of the number of motor vehicles, vehicular energy consumption and CO_2 emissions in Taiwan during 2007–2025. Results showed that the vehicle fleet, energy demand and CO_2 emitted by the road transportation system continued to rise at the annual growth rates of 3.64%, 3.25% and 3.23% over the 18 years from 2007 to 2025. The simulation of different economic development scenarios revealed that the lower and upper bound values of allowable vehicles in 2025 are 30.2 and 36.3 million vehicles, respectively, with the traffic fuel consumption lies between 25.8 million kiloliters to 31.0 million kiloliters. The corresponding emission of CO_2 will be between 61.1 and 73.4 million metric tonnes in the low- and high-scenario profiles.

In Taiwan, the government considers the zero-emission scooters to be a sustainable form of transport like walking, cycling and public transport, which play a vital role to support sustainable urban mobility. Therefore, the development of zero-emission scooters is an important strategy in constructing the sustainable transport network of Taiwan. It is also the government's priorities about the policy of emission-reduction and energy-conservation in the transportation sector. Recently, Taiwan launched a new program for subsidy of purchasing zero-emission scooters, which aimed to shift the petroleum powered scooters to the electric scooters. Hwang (2010) provided an update review of the promotional programs in developing zero-emission scooters in Taiwan. It introduces the status of the establishment and progress of policy, standards, subsidies to users and manufacturers, practice infrastructure, and technology development. Moreover, the contribution of replacing petrol scooters by zero-emission scooters such as battery-powered electric scooters and fuel cell scooters to reduction in greenhouse gas (GHG) emission and improvement in energy efficiency is evaluated.

Trappey et al. (2012) uses a system dynamics approach designed to construct a model for evaluating the green transportation policy on Penghu Island. Simulations are conducted to model green transportation system behavior and related policy effects in a smaller, controlled environment before creating policies for Taiwan Island that will impact the lives of over 23 million people. As demonstrated in the scenario analyses, none of the green transportation policies alone can achieve the 50% carbon reduction goal in 2015 for the Penghu Low Carbon Island. Therefore, the Taiwanese government has planned additional actions and measures beyond green transportation. For instance, there are plans to expand and promote a variety of renewable energy sources, substitute LED street lamps for traditional ones, and subsidize the purchase of energy-saving appliances.

3. Energy consumption structure of the transport sector in Taiwan

As shown in Table 1, Taiwan's total energy use in the transport sector was 15,546.3 MOLE in 2010 (MOEABOE, 2012a), accounting 12.92% of the national final energy use. In addition, the transport sector totally emitted 35.317 Mt-CO_2 (MOEABOE, 2012c) in 2010, with a share of 13.9% of national GHG emissions. Based on the calculation of these data, the carbon intensity of the transport sector is 0.00227 Mt-CO_2/MLOE, while that of entire nation is 0.00211 Mt-CO_2/MLOE. The possible explanation for the closeness of these two values may be that half of Taiwan's primary energy supply is from crude oil and petroleum products. Meanwhile, the

Table 1
Energy consumption structure of the transport sector of Taiwan in 2010.

Energy resource	Oil products						Power	Total
Fuel type unit transport way	LPG (million liter)	Gasoline (million liter)	Aviation fuel (million liter)	Diesel (million liter)	Fuel oil (million liter)	Energy use subtotal (MLOE)	(MLOE)	(MLOE)
International aviation	–	–	2473.9	–	–	2199.1	–	2199.1
Domestic aviation	–	–	96.4	–	–	85.7	–	85.7
Highway	133.1	9722.1	–	4414.0	–	12,643.9	–	12,643.9
Railway	–	–	–	31.9	–	29.7	286.7	316.4
Domestic water	–	–	–	111.5	184.8	301.2	–	301.2
Total	133.1	9722.1	2570.3	4557.4	184.8	15,259.6	286.7	15,546.3

Data source: MOEABOE (2012a)