

## SCENARIO ANALYSIS ON ROAD TRANSPORT SERVICE: ENERGY CONSUMPTION AND GHG EMISSIONS

Pham Thi Hue<sup>1,2</sup>, Nguyen Thi Anh Tuyet<sup>1,\*</sup>, Hoang Xuan Co<sup>3</sup>

<sup>1</sup>*School of Environmental Science and Technology, Hanoi University of  
Science and Technology, No.1, Dai Co Viet Road, Ha Noi, Vietnam*

<sup>2</sup>*Department of Environmental Engineering Technology, University of  
Transport Technology, No.54, Trieu Khuc Street, Ha Noi, Vietnam*

<sup>3</sup>*Department of Environmental Ecology, VNU University of Science,  
Vietnam National University, No. 344, Nguyen Trai Road, Ha Noi, Viet Nam*

\*Email: tuyet.nguyenthianh@hust.edu.vn

Received: 1 July 2020; Accepted for publication: 14 January 2021

**Abstract.** This study aims to assess the energy consumption and greenhouse gas (GHG) emissions of Vietnam's road transport service by establishing different scenarios during the period 2015-2050. Four scenarios are developed toward improving energy efficiency, floating automotive industry strategy, and then energy demands, the GHG emissions from road transport in these scenarios to be estimated. Transportation demand, technology penetrative rate, fuel type, fuel economy, emission standard, and impact of other factors on emissions are bases of the selected input data. Calculator 2050 is used as a support tool for interface and calculation. The results are shown as following: Energy consumption and the GHG emissions of road transport service will reach 11.28 Mtoe and 32.07 MtCO<sub>2e</sub> in 2030 as well as 36.95 Mtoe and 105.04 MtCO<sub>2e</sub> in 2050 in the basic scenario, with the annual average growth rate reaching 6.4 %. The subscription to the increase of energy consumption and the GHG emissions of freight transport services is higher than that of passenger transport service. In the best case, the energy consumption and GHG emissions will decrease by 27.4 % and 30.3 %, respectively in 2030 and these percentages will rise to 37.8 % and 50.7 % in turn in 2050 compared to the basic scenario. This reduction is mainly due to the usage of alternative fuels/vehicles in these activities.

**Keywords:** GHG emissions, road transport development scenarios, Calculator 2050.

**Classification numbers:** 3.4.5, 3.8.2, 5.10.2.

### 1. INTRODUCTION

The energy consumption of Vietnam's road transport service has been increasing significantly in recent years. Regardless of some performed solutions, the energy intensity of this activity still tends to rise, as it reached 0.51 kgoe/USD in 2012 and 0.62 kgoe/USD in 2018 [1]. This indicator was higher than that of other countries such as EU15, Spain, and Japan. Thus,

it may lead to higher energy demand and GHG emissions as well as affecting the environment and living standard. To achieve dual targets of reducing both energy consumption and the GHG emissions from passenger and freight transport services, it is essential to plan out different scenarios to determine these parameters in a long time to figure out solutions toward sustainable development.

Over the world, some studies related to the forecast of energy consumption and the GHG emissions have been carried out for both passenger and freight transportation as following: These studies have estimated the historical energy consumption, air pollutants trends and project their impact on road passenger transport in Mexico City Metropolitan area in the period 2008-2028 [2] and London until 2050 for road freight transport [3] as well as in China the period 2010-2050 [4, 5]. Mitigation potential of fuel consumption and the GHG emissions of public passenger transport in Nepal were analyzed [6] and also that of road freight transport in Finnish up to 2030 [7]. In the UK, factors that influence freight transport demand, truck fuel consumption, and related CO<sub>2</sub> emissions are classified into six categories about different levels of logistical decision-making. Three scenarios have been constructed to assess CO<sub>2</sub> emission levels of road freight transport in 2020 [8]. In Bahrain, an integrated approach was developed for the study to access the measures to reduce CO<sub>2e</sub> emissions for the road passenger transport sector [9]. Some other related studies have also been carried out in China [10, 11, 12]. Besides the researches, the development of forecasting and planning tools for timely mitigation solutions has been on focus. Among the tools, Calculator 2050, which was developed by the UK has been used in developing long-term energy use and the GHGs emission scenarios for industrial sectors, agriculture, transportation, and waste (up to 2050). Besides, the development of this national tool created a flexible structure that can be adjusted and altered to take account of structural differences between the UK economy and other economies. Therefore, when using the Calculator 2050, each country can create its own structure and conditions. Several countries have developed to use the tool including Australia, Japan, Korea, Mexico, Brazil, Indonesia, China, India, Thailand, Taiwan, and Viet Nam [13]. For the transportation sector, Calculator 2050 has been used in China to forecast energy demand and CO<sub>2</sub> emissions for the transport sector in general and road transport in particular [11, 14]. In Nigeria, this tool is also used to establish carbon mitigation scenarios by 2050 [15].

In Viet Nam, some studies have been implemented for the entire transport sector [16, 17] or only transport in large cities [18]. Some studies about transportation focus on low carbon social development of freight transport up to 2030 [19] and a recent report has also been made by the World Bank; however, it focuses on logistics transport expenses of freight transport [20].

Thus, the number of researches focusing on environmental scenarios in passenger and freight transport services in our country is very limited. The purpose of this study is to develop GHGs mitigation scenarios for road transport service (passenger and freight) in Viet Nam in the period 2015-2050. Also, its result may assist in adjusting and planning new policies, strategies to improve the traffic as well as energy consumption for this transport section.

## 2. METHODOLOGY

### 2.1. Identify energy consumption and GHG emissions

Energy consumption of road transport services (EC<sub>y</sub>) is determined as following [11]:

$$EC_y = \sum_i EC_i = \sum_{x,f} TV_{x,f,y} * TR_{x,y} * EL_{x,f,y} * PV_{x,y}^{-1} \quad (1)$$

in which: TV<sub>x,f,y</sub> is activity level (in this case the total traffic demand of passenger/freight,

passenger/ton.km);  $TR_{x,y}$  denotes the share for vehicle type  $x$  in year  $y$ ;  $EL_{x,f,y}$  (ktoe/xe.km) is the amount of energy consumption on each unit of traveling distance of vehicle  $x$  using fuel  $f$  in year  $y$ ;  $PV_{x,y}$  (passenger or ton/vehicle) is the load factor of vehicle  $x$  in year  $y$ ; when  $x$  is a vehicle type,  $f$  is fuel type;  $i$  is transport mode;  $y$  is the calendar year.

The GHG emission comes from road transport service is calculated as following [21]:

$$E_y = \sum_n E_n = \sum_n EC_y * EF_n \quad (2)$$

in which:  $E_y$  denotes GHG emissions;  $EF_n$  are emission factors of emissions  $n$  ( $CO_2$ ,  $CH_4$ ,  $N_2O$ ) and defined in sources of IPCC, UNEP, and other Asian countries [22-24].

## 2.2. Scenario development using Calculator 2050

This study uses Calculator 2050 as a support tool in interface and calculation to showcase a comparative estimation of energy balance and GHG emissions. The energy balance is to match the primary energy supply to the final energy demand. It uses a set of existing and future technologies to ensure that energy supply satisfies the varying demand. The demand sectors of this tool include industry, agriculture, transport, residence, and commerce. The demand is defined by the user which is selected of these demand sectors. The energy supply is determined by the Calculator 2050 to compare between demand and supply based on the user selection. The primary energy supply types consist of coal, gas, oil, and biomass; the GHG emission sources in the calculator 2050 are grouped into fuel combustion, industrial process, solvent, and forestry (LULUCF), waste, other, bioenergy credit, carbon capture, and storage; then energy consumption and the GHG emissions are estimated [15]. However, this study focuses on road transport services. The structure of the tool and its input-output data for road transport services is shown in Figure 1.

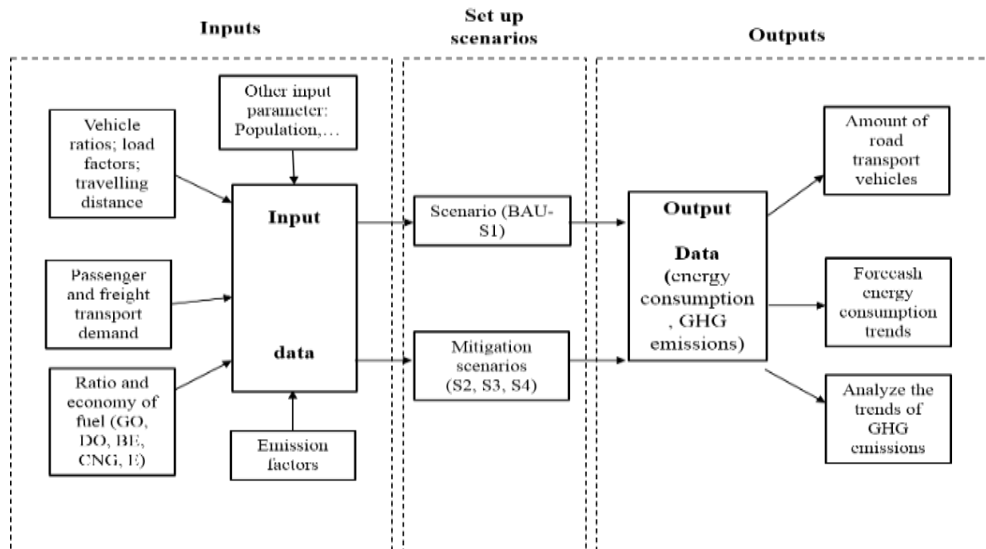


Figure 1. Structure of Calculator 2050 for the developed scenarios.

Four scenarios are set up for road transport including scenario 1 (S1), which is called the basic scenario (BAU) and does not consider any ties of decreasing energy consumption and the GHG emissions. Three mitigation scenarios are scenario 2 (S2), scenario 3 (S3), and scenario 4 (S4). These scenarios are established as follows:

S1: Scenarios are commonly developed, without considering constraints on energy consumption and emissions (no efforts); S2: Implement to achieve the objectives of the strategy and planning (little efforts); S3: More determined but not final result (greater efforts); S4: The maximum level is achieved, all barriers are basically removed (highest efforts).

Types of the vehicle which are employed and signed for setting up comprise motorcycle (MC), small car (SM), bus (BU), light-duty vehicle (LDV) and heavy-duty vehicle (HDV). Types of fuel consumed are signed as gasoline (GO), diesel (DO), compressed natural gas (CNG), biofuel E5/E10 (BE), and electricity (E).

*The established scenarios are based on:*

- For the base year of 2015: Vietnam's Paris Agreement in 2015 committed that: "...8 % of the total greenhouse gas emissions will be reduced in comparison to normal development trajectory and the target can rise to 25 % when receiving international support using bilateral, multilateral cooperation and performing new mechanisms" [25] and Decree No 2359/QD-TTg dated 22/12/2015 of the Prime Minister approving the national GHGs inventory system with the annual GHG emissions reduction target by at least 1.5 %-2 % in 2020-2030 and 2030-2050 [26].

- Some other bases are included such as metro lines were oriented to implement; E5 gasoline has been used since December 01, 2015 [27]. The approval of adjusting the transportation development strategy, Vietnam road transport until 2020 and orientations until 2030 sets the aim to forecast road passenger rotation demands; The approval of national strategy about climate change sets the aim of using CNG for the bus; National strategy about green growth in the period 2011-2020 and vision until 2050 sets the aim of reducing GHG emissions annually and the regulation of the Prime Minister about using new and renewable energy for transport vehicles [28].

- In a recent study, our group has analyzed the trend of rising the energy intensity of road transport and proposed a few solutions such as controlling motorcycle vehicles growth and encouraging the usage of public transport; improving energy economy (consumption per kilometer); enhancing the penetration of new technologies such as electric vehicles and gradually increasing the use of environmentally friendly fuels such as ethanol biofuels (E5) and CNG [1].

The input source, which comes from the General Statistics Office, consisting of passenger and freight transport demands, population; vehicle ratios, load factors, traveling distance, ratio, and economy of fuel was referenced from previous studies. Further details will be illustrated in the result descriptions of the scenarios.

### **3. RESULTS AND DISCUSSION**

#### **3.1. Scenarios established for Vietnam's road transport services**

Transport demand is determined based on the volume of transport per kilometer and used for each mode of transport. Passenger transport demands achieved an average annual growth rate of 11.2 % in 2005-2010 and 9.6 % in 2010-2015. Meanwhile, the growth rate of road passenger transport services reached 12.4 % in 2005-2010 and 8.8 % in 2010 - 2015. Also during these two periods, air passenger transport service accounted for 13.7 % and 14.7 %, respectively [29]. Thus, its passenger traffic demand tends to decrease due to the shift to another transport mode such as aviation transport and possibly railway in the future. According to the plan of road transport No 356/QD-TTg dated 25/2/2013, the targeted average annual accelerating rate of

passenger transport demand would be 8.6 % in 2030. A study about traffic in Viet Nam showed that passenger transportation demands will reach 2,235 billion passenger.km in 2050 [16]. Thus, the selected growth rate would be 9.2 % in 2016 - 2030 and 8.6 %/year in 2030 - 2050, while passenger traffic demand will reach 2,013 billion passenger.km in 2050. Moreover, due to mitigation targets, in S2 and S3 as well as S4 these percentages will reduce by 0.27 %/year, 4.2 %/year, and 5.8 %/year, respectively, when compared to BAU.

Similarly, the freight transport demand had an average annual growth rate of 16.7 % in the period 2005 - 2010 and 7.3 % in the period 2010-2015 [29]. Thus, it is obvious that the traffic demand for freight transport services in general and by road, in particular, is having a downward trend. Moreover, according to pre-planned targets for development strategy of road transport sector No 356/QD-TTg dated 25/2/2013, the annual freight traffic demand would reach 7.44 %/year in 2020 - 2030 [28]. Thus, this study assumes that the average annual growth rate will reach 7.8 % in 2016 - 2030 and 7.44 % in 2030 - 2050. For S2, S3, and S4, due to applying logistics management solutions, intensifying logistics tasks to reduce the transport volume, gaps limitation, each scenario after assumption will experience falls. To be specific, the demand amount in S2, S3, and S4 will decrease by 1 %, 3 %, and 7 %, respectively, in comparison to that in BAU.

Types of alternative fuels for vehicles in each scenario are also established. Biological fuel is implemented according to decree No 1855/QD-TTg dated 27/12/2007 to replace about 5 % of the old one with new and renewable energy in 2020 and then by about 11 % in 2050. CNG fuel used in BU, according to the target in decree No 2139/QD-TTg dated 5/12/2011, is bound to achieve the replacement ratio of 20 % in 2020 and 80 % in 2050, respectively. However, until this time, the ratio has not met the expected target, so the study will establish targets for 2030 and 2050.

Electricity vehicles have been widely used in many countries over the world, yet in Viet Nam, they are not popular and most of them are motorcycle. However, complying with the Prime minister's decision No 2075/QD-TTg dated 8/11/2013 approving the science and technology market development program up to 2020, electric vehicles are one of the alternative technology will develop in the following years, especially electric motorcycle. In fact, electric vehicle usage will help cut down a considerable amount of consumed energy. The world bank's report has pointed out that the energy consumption of an electric motorcycle and a car are 68.4 kJ/km and 720 kJ/km, respectively [30] while using gasoline, it would be 765.7 kJ/km and 4,023 kJ/km [18, 31]. In this study, the ratio of electrical vehicles is established to rise ascendingly in each scenario.

Fuel economy is referred from previous studies for transport vehicles in Viet Nam [18, 31] and regulations of fuel standard for road transport vehicles. LDV and HDV have not been really effective over the years with their high energy intensity. This issue has been proved in our previous study [1]. Thus, efficiency improvement will gain from S2. It is assumed to be 0.3 %/year for S2, 0.5 %/year for S3, and 1 %/year for S4. A study in China established this improvement of 0.3 %/year for LDV and LDV in the period 2008-2030 [10].

The ratio of each vehicle (% of passenger.km) is determined by the traveling distance of it per year [32], load factor [33], and the number of vehicles. Besides, the ratio of BU will rise and that of the motorcycle will fall according to strategical plans. The population rate is chosen for the basic year and the forecast for growth rate in recent data. According to statistics, that rate in each 5-year period from 2020 to 2050 will be 5.3 %, specifically 1.06 % per year [29].

The input parameters of the scenarios are summarized in Table 1.

### 3.2. Discussing the potential of reducing energy consumption and GHG emissions

Strategical orientations of the transport sector are set until 2020 and vision 2030 as well as goals of reducing the GHG emissions in 2030 and 2050 in the 2015 Paris Commitment and resolutions relating to the national GHG statistical system in 2015; time markers in focus for profound analysis include basic years 2015, 2030 and 2050. Thus, the scenarios are analyzed in two periods of 2015 - 2030 and 2030 - 2050.

Table 1. The major assumption of established scenarios.

Data inputs	Years	S1	S2	S3	S4
Passenger and freight transport demand (billion passenger/ton.km)	2015	155/230	154/228	148/231	140/207
	2030	481/618	480/612	461/594	436/555
	2050	2,013/2,189	2,008/2,167	1,927/2,104	1,821/1,966
BE (%) for MC, SM, LDV	2015	0	0	0	0
	2020	0	3	5	15; LDV: 7
	2050	0	7	11	25; LDV: 7
CNG (%) for BU	2015	0	0	0	0
	2030	0	5	10	20
	2050	0	10	30	50
E (%)	2050	0	MC: 5; SM: 3; and BU: 2	MC: 7; SM: 5; and BU: 4	MC: 10; SM: 7; and BU: 7
Fuel economy	2025-2050	0	Efficiency improvement of LDV and HDV: 0.2 %/year for S2, 0.5 %/year for S3 and 1 %/year for S4		
Load factors (passenger or ton/vehicle)	2015	MC: 1.2; SM:2; BU:35; LDV: 1.2; HDV: 8.4			
	2030	MC: 1.23; SM: 2.18; BU: 8; LDV: 1.7; HDV: 9.2	MC: 1.25; SM: 2.22; BU: 38.58; LDV: 1.7; HDV: 9.2	MC: 1.3; SM: 2.3; BU: 40.06; LDV: 1.7; HDV: 9.2	MC: 1.33; SM: 2.37; BU: 41.17; LDV: 1.7; HDV: 9.2
	2050	MC: 1.26; SM: 2.36; BU: 41; LDV: 2.5; HDV: 9.6	MC: 1.3; SM: 2.43; BU: 42.16; LDV: 2.5; HDV: 9.6	MC: 1.39; SM: 2.6; BU: 45.12; LDV: 2.5; HDV: 9.6	MC: 1.45; SM: 2.73; BU: 47.34; LDV: 2.5; HDV: 9.6
Vehicle ratio (% of passenger/ton.km)	2015	MC: 32; SM: 1.4; BU: 37.3; LDV: 4.9 ; HDV: 11.7			
	2030	MC: 33.7; SM: 1.6; BU: 32.8; LDV: 5.2; HDV: 14.8	MC: 28.7; SM: 1.7; BU: 36.8; LDV: 5.2; HDV: 14.8	MC: 28.7; SM: 1.8; BU: 37.2; LDV: 5.2; HDV: 14.8	MC: 21.7; SM: 1.8; BU: 42.8; LDV: 5.2; HDV: 14.8
	2050	MC: 33.7; SM: 1.6; BU: 32.8; LDV: 4; HDV: 16	MC: 26.1; SM: 1.8; BU: 38.8; LDV: 4; HDV: 16	MC: 20.0; SM: 2; BU: 43.7; LDV: 4; HDV: 16	MC: 9; SM: 2.4; BU: 50.8; LDV: 4; HDV: 16

The economic sectors considered in the model include industry, agriculture, transport, resident, and commerce. The final energy demand for the transport sector will hold a contribution of 21.3 % in 2030 and 26.5 % in 2050 of the whole economy, while it occupied 16.8 % in 2015. Only for road transport service (R), the outcomes of setting up scenarios help to determine levels of energy consumption and the GHG emissions as shown in Figure 2.

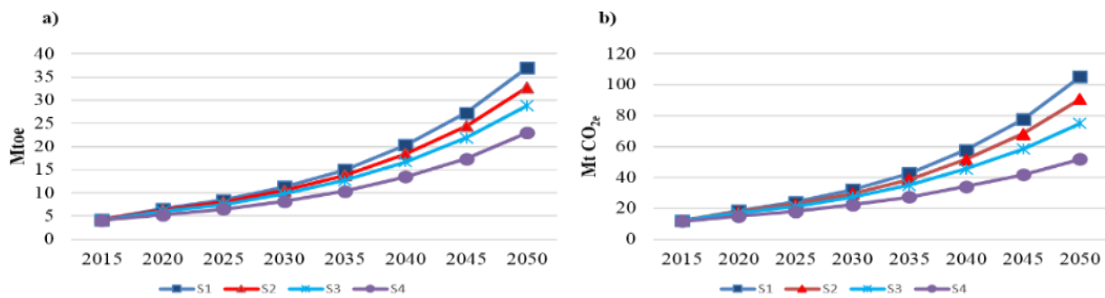


Figure 2. Energy consumption and GHG emission of Vietnam's road transport service in different scenarios.

In the base scenario, the estimated result shows that the total energy consumption of road transport services will reach 11.28 Mtoe in 2030, 2.6 times as high as that in 2015 (4.26 Mtoe), and reach 36.95 Mtoe in 2050, 10.2 times as high as that in the base year. The average annual growth will be 6.7 % in 2015 - 2030 and 6.1 % in 2030 - 2050. The calculated results of the energy consumption of this sector in 2015 are similar to that of previous publications. Figure 3 shows that the energy consumption of S1 in 2015 is higher than 1.41 Mtoe using table IO in 2012 and less than 0.14 Mtoe when using table IO in 2016 [1; 34]. Next, the GHG emissions would have also risen to 32.07 MtCO<sub>2e</sub> in 2030 and 105.04 MtCO<sub>2e</sub> in 2050 with the same growth rate as energy consumption. In our study, the population of truck vehicles (LDV and HDV) has reached 0.86 million in 2015, while in the statistics data of the Ministry of Transport it was 0.85 million vehicles [35].

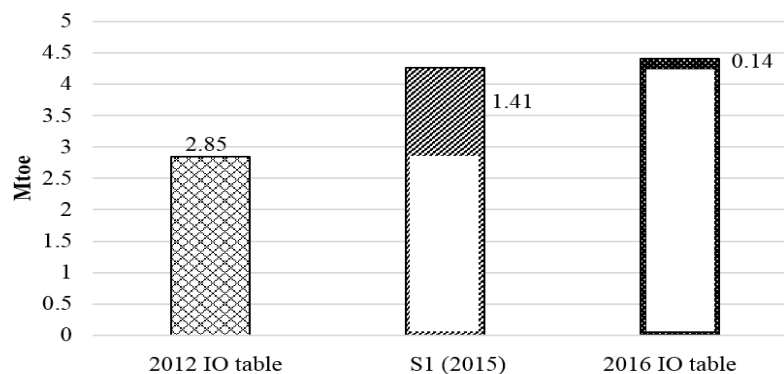


Figure 3. Comparison of the energy consumption of road transport services.

In mitigation scenarios, the energy consumption and GHG emissions of road transport services fall considerably due to these scenarios are replaced by input factors as in Table 1. The potential of reducing energy consumption is corresponding to 7.1 %, 13.5 %, and 27.4 % in 2030 as well as 11.4 %, 22 %, and 37.8 % in 2050. Among two types of transport services, the freight transport service (RF) occupied a higher amount of the energy consumption and GHG

emissions than that of the passenger transport service (RP) every year. Figure 4 shows the GHG emissions shares in 2030 and 2050.

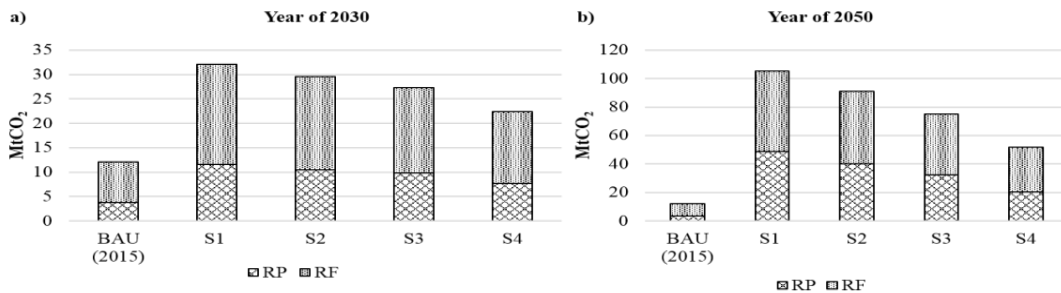


Figure 4. The GHG emissions share of road transport services (passenger and freight).

Road transport services in Viet Nam mostly use gasoline and oil, which took approximately 100 % in 2015. However, when replacing conventional fuel with BE, CNG, and E (Table 1) in vehicles, traditional energy consumption is undeniable in 2030 and 2050 (Figure 5). In 2050, the alternative fuel consumption in scenarios is as follows: At S2, BE is 0.4 Mtoe, CNG is 0.9 Mtoe and E is 0.2 Mtoe; at S3, BE is 0.7 Mtoe, CNG is 2.9 Mtoe and E is 0.3 Mtoe; at S4, BE is 0.7 Mtoe, CNG is 5.3 Mtoe and E is 0.6 Mtoe. The results showed that the usage of traditional fuels including gasoline and diesel would tend to decrease from S1 to S4, whereas environmentally friendly fuels such as BE, CNG, and E would increase gradually. This contributes a significant deal to ensuring national energy security and the GHG emissions reduction potential.

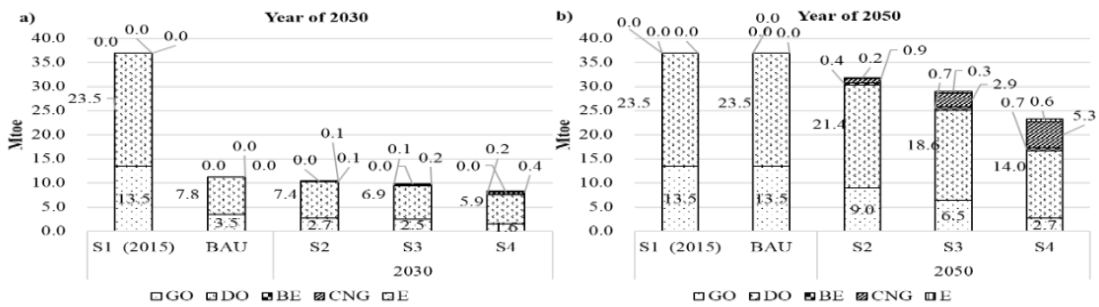


Figure 5. Energy consumption of each alternative fuel type used in road transport at S1, S2, S3, and S4.

In the mitigation scenarios, the energy consumption and GHG emissions experience a considerable decrease by fuel replacement, transfer partly from road transport to other types such as railway, aviation, and fuel economy improvement. The energy consumption and GHG emissions have a similar relation; therefore, the reduction rate of GHG emissions is assessed to compare with the national strategical target. The study has shown the reduction parameters in mitigation scenarios of road transport services in general as well as in each section of freight and passenger services, in Table 2.

As result, the expected GHG emissions in 2030 and 2050 are significant. If it is compared with the targets set in the 2015 Paris commitment, the potential is approximately equal or even higher than the highest target (25 %) for the road transport service sector and each separate transport mode. The annual GHG emission reduction potential of road transport service may be equal to or higher in S3 and S4 in two periods 2015-2030 and 2030-2050 (Table 2). To achieve



the expected reduction of energy consumption and GHG emissions as scenarios, it is necessary to perform policies, solutions of fuel and vehicle technology replacement for road transport service strictly and comprehensively.

*Table 2. GHG emissions in the mitigation scenario compare to BAU.*

Mitigation scenarios compared to BAU	GHGs mitigation potential compared to BAU (%)						Annual GHGs reduction in 2015-2030 (%)	Annual GHGs reduction in 2030-2050 (%)
	2030			2050				
	R	RP	RF	R	RP	RF	R	R
S2	7.8	10.6	6.2	13.5	17.2	10.3	0.8	0.8
S3	14.8	15.7	14.3	28.5	33.4	24.3	1.5	1.7
S4	30.3	34.1	28.0	50.7	58	44.2	6.7	5.0

The energy consumption as well as GHG emissions of the transport field has a significant impact on Vietnam's entire economy. Thus, the analysis of energy demand reduction potentials of this field will be useful. The sensitivity analysis was conducted to evaluate quantitatively the transport sector lever on all energy consumption of the country. Therefore, the transport sector levers were changed from S1 (no efforts) to S2 (little efforts); S2 to S3 (greater efforts), and then S3 to S4 (highest efforts), while other sectors are kept at BAU (S1) levels. This is the next work that research will continue to perform and complete.

#### 4. CONCLUSION

This study has established four scenarios in the period 2015-2050. The final energy demand for the transport sector shares 21.3 % in 2030 and 26.5 % in 2050 of the whole economy. Only for road transport service, the results of the energy consumption and GHG emissions will reach 11.28 Mtoe and 32.07 MtCO<sub>2e</sub> in 2030 as well as 36.95 Mtoe and 105.04 MtCO<sub>2e</sub> in 2050 in BAU, with an annual average growth ratio reaching 6.4 %. The subscription to the increase of energy consumption and emission of freight transport service is higher than that of the passenger section. In the best case, the GHG emissions would be reduced by 30.3 % in 2030 and 50.7 % in 2050 compared to BAU. For mitigation scenarios of S2, S3, and S4, the annual GHG emissions reduction potential as well as energy consumption of road transport service activity in the period mentioned, would be respectively 0.8 %/year, 1.7 %/year, and 5.0 %/year in the period of 2030-2050. To achieve this, it is necessary to conduct policies, fuel solutions, and traffic technology replacement for road transport activities in Viet Nam strictly and comprehensively.

**Acknowledgements.** The authors wish to thank School of Environmental Science and Technology, Hanoi University of Science and Technology for the academic supports.

**CRedit authorship contribution statement.** Pham Thi Hue: Methodology, Investigation. Nguyen Thi Anh Tuyet: Formal analysis, Supervision. Hoang Xuan Co: Supervision.

**Declaration of competing interest.** The authors have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

#### REFERENCES

1. Hue P. T. and Tuyet N. T. A. - Evaluation of energy intensity of transport service sectors

- in Vietnam, *Environmental Science and Pollution Research* **27** (2020), Issue 01.
2. Carlos C. B. and Claudia S. P. - Sustainable passenger road transport scenarios to reduce fuel consumption, air pollutants and GHG (greenhouse gas) emissions in the Mexico City Metropolitan Area, *Energy* **66** (2014) 624-634.
  3. Zanni A. M. and Bristow A. L. - Emissions of CO<sub>2</sub> from road freight transport in London: Trends and policies for long run reductions, *Energy Policy* **38** (2010) 1774-1786.
  4. Hao H., Wang H. and Ouyang M. - Fuel consumption and life cycle GHG emissions by China's on-road trucks: Future trends through 2050 and evaluation of mitigation measures, *Energy policy* **43** (2012) 244-251.
  5. Hao H., Geng Y., Li W. and Guo B. - Energy consumption and GHG emissions from China's freight transport sector: Scenarios through 2050, *Energy policy* **85** (2015) 94-101.
  6. Pradhan S., Ale B. B. and Amatya V. B. - Mitigation potential of greenhouse gas emission and implications on fuel consumption due to clean energy vehicles as public passenger transport in Hathmandu Valley of Nepal: A case study of trolley buses in Ring Road, *Energy* **31** (2006) 1748-1760.
  7. Heikki L., Erika K., Markus P., Pekka S., Petri T. and Alan M. - Decarbonizing road freight in the future – Detailed scenarios of the carbon emissions of Finnish road freight transport in 2030 using a Delphi method approach, *Technological Forecasting & Social Change* **81** (2014) 177-191.
  8. Maja I. P. and Alan C. M. - Forecasting the carbon footprint of road freight transport in 2020, *International Journal of Production Economics* **128** (2010) 31-42.
  9. AlSabbagh M., Siu Y. L., Guehneemann A. and Barrett J. - Integrated approach to the assessment of CO<sub>2e</sub>-mitigation measures for the road passenger transport sector in Bahrain, *Renewable and Sustainable Energy Reviews* **71** (2017) 203-215.
  10. Ou X., Zhang X. and Chang S. - Scenario analysis on alternative fuel/vehicle for China's future road transport: Life-cycle energy demand and GHG emissions, *Energy Policy* **38** (2010) 3943-3956.
  11. Gambhir A., Tse L. K. C, Tong D. and Botas R. M. - Reducing China's road transport sector CO<sub>2</sub> emission to 2050: Technology, costs and decomposition analysis, *Applied Energy* **157** (2015) 905-917.
  12. Peng B., Du H., Ma S., Fan Y. and Broadstoc D. – Urban passenger transport energy saving and emission reduction potential: A case study for Tianjin, China, *Energy Conversion and Management* **102** (2015) 4-16.
  13. Tuyet N. T. A and Hue P. T. - Experience in using Calculator 2050 in some countries and suggesting usage directions for the road transport sector in Vietnam, *Environment Magazine* **11** (2019) 32-34 (in Vietnamese).
  14. Amakpah S. W., Liu, G., Hao, Y. and Xu L. - Energy flow analysis of China 2050 Pathways Energy Calculator with special emphasis on transportation, *Energy Procedia* **104** (2016) 275 – 280.
  15. Michael O. D., Nnaemeka V. E. and Memanuel C. D. - Pathways for low carbon Nigeria in 2050 by using NECAL2050, *Renewable Energy Focus* **29** (2019) 63-77.
  16. Institute for Transport Policy Studies and Clean Air Asia - A Study on a Long-term Transport Action Plan for ASEAN (Vietnam), Available online: <http://cleanairasia.org/study-of-long-term-transport-action-plan-for-aseanregion-lpa-project/> (accessed on 23 May 2017).
  17. JICA and Ministry of Transport, Vietnam - The Comprehensive study on the sustainable

- development of the transport system in Vietnam (VITRANSS 2), 2010.
18. Schipper L., Tuan L. A. and Orn H. - Measuring the Invisible, Quantifying Emissions Reductions from Transport Solutions-Hanoi Case Study, World Resources Institute, 2008.
  19. Clean Air Asia and the World Bank. - Accessing Asia: Air Pollution and Greenhouse Gas Emissions from Road Transport and Electricity, 2012.
  20. World Bank - Potential Climate Change Mitigation Opportunities in the transport sectors in Vietnam. RCEE Energy, Environment JSC (Vietnam) and Full Advantage Co., Ltd, 2009.
  21. Ministry of Industry and Trade, Industrial Safety Techniques and Environment Agency – Introduction and usage document of Calculator 2050 in Vietnam, 2016, <http://vietnamcalculator2050.atmt.gov.vn/>.
  22. IPCC - Guidelines for National Greenhouse Gas Inventory, volume 2 energy, 1996, 2006.
  23. UNEP - Emission Inventory Manual, Atmospheric Brown Clouds, 2012.
  24. Nansai K., Moriguchi Y. and Tohmo S. - Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables, Center for Global Environmental Research, 2002.
  25. MONRE, Ministry of Natural Resource and Environment - Intensity Nationality Determination Contribution of Viet Nam (INDC), 2015.
  26. Prime Minister – The decree No 2359/QĐ-TTg dated 22/12/2015 on approval of the national GHGs inventory system, 2015 (in Vietnamese).
  27. Prime Minister - The Decree No 53/2012/QĐ-TTg dated 20/11/2012 on publishing routes of applying the rate of combining biological fuel with traditional one, 2012 (in Vietnamese).
  28. Prime Minister – The Decree No 356/QĐ-TTg dated 25/02/2013 on approval of adjusting the development strategy of Vietnam transport until 2020, vision until 2030, 2013 (in Vietnamese).
  29. General Statistical Office - Statistical Yearbook Vietnam in 2018, Statistical Publishing House, 2019.
  30. World Bank - Potential Climate Change Mitigation Opportunities in the transport sectors in Vietnam. RCEE Energy, Environment JSC (Vietnam) and Full Advantage Co., Ltd, 2009.
  31. Tung H. D., Tong H. Y., Hung W. T. and Anh N. T. N. - Development of emission factors and emission inventories for motorcycles and light-duty vehicles in the urban region in Vietnam, *Science of the Total Environment* **409** (2011) 2761-2767.
  32. Clean Air Asia and World Bank - Accessing Asia: Air Pollution and Greenhouse Gas Emissions from Road Transport and Electricity, 2012.
  33. Clean Air Asia - Transport Emissions Evaluation Model for Projects (TEEMP). <https://cleanairasia.org/transport-emissions-evaluation-model-for-projects-teemp>, 2010.
  34. Hue P. T. and Tuyet N. T. A - Energy consumption and air emission inventory for Transportation sectors of Viet Nam, *Vietnam Journal of Science and Technology* **56** (2018), 30-35.
  35. Ministry of Transport: <http://mt.gov.vn/tk/Pages/phantich.aspx>.