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DECOMPOSING THE INFLUENCING FACTORS OF ENERGY INTENSITY IN THE PASSENGER TRANSPORTATION SECTOR IN INDONESIA

Indonesia's transport sector has experienced rapid growth that has caused excessive fossil fuel energy consumption. Over 2000 to 2016 total final energy consumption in Indonesia's transport sector has grown by 10% per annum so that transport now provides a large and rapidly growing component of total energy use. This study analyzes the specific characteristics of energy intensity in the transportation sector in Indonesia from 2000 to 2016 by employing a multiplicative Log Mean Divisia Index-II. The passenger transport sector in Indonesia, including the four modes of road, rail, water and air is examined in this study. Overall, the decline in energy intensity in passenger transport is attributed to the intensity effect. In passenger transport, the improvement of intensity effect was found to have significantly reduced the overall aggregate energy intensity, while the change in structural effect was found to have a relatively small reduction in the aggregate energy intensity.

Keywords: energy efficiency, passenger transportation, energy intensity, Indonesia

1 Introduction

Indonesia's transportation energy consumption is rapidly increasing, primarily due to rising economic activity and population growth. As an emerging economy and the fourth most populous country in the world [1], Indonesia's economic growth has had around 6% growth every year since 2010, leading to an increase in the mobility of the middle class [2]. Indonesia's transportation sector has gone through the rapid development, causing a significant use of fossil fuel energy consumption. This sector uses more than 60% of Indonesian's total oil use, approximately 70% of which is consumed in road transportation [2].

In the last decade, Indonesia had experienced several increases in fuel prices² (see Table 1). Subsidies for fossil fuels were increasing as a portion of the national budget, although the recent price increase was the lowest in the world, particularly for a net importing country [3]. Starting from 2005, the Indonesian Government had cut subsidies for energy and increased fossil fuel prices more than threefold. The purpose of this energy price reform was not only to limit the difference between international and domestic prices but also to bring decrease the burden on the state budget; as the budget for fuel subsidies accounted a substantial percentage in the national state budget [4].

Some studies [7-8] show that an increase in energy price can significantly improve energy efficiency. Therefore, the energy price instrument is one of the essential tools for energy reform and subsidies for energy is a key determinant of energy prices. The most common definition of an energy subsidy is a payment from government to consumer or producer in order to control energy prices [9-10]. In Indonesia, energy subsidies are mainly used by the government to control the energy price lower rather than the economic production cost.

Since the transportation sector in Indonesia is very complex and the statistical energy data in the transportation sector is limited, this study only investigates Indonesia's passenger transportation for a limited period. This study examines all the four modes of the transportation system in Indonesia: road, rail, water and air. Those modes of transport are used to measure the level of energy intensity in the passenger transport sector. This study is crucial for Indonesia's government in order to develop policies to improve energy efficiency, as well as to investigate the driving factors that affect the changes in transportation energy usage.

2 Literature review

The decomposition indices method has been extensively employed in measuring the driving factors behind the changes in energy used in transport. Authors of [11] investigated changes in the structure of passenger transport energy consumption in eight OECD countries from 1970 to 1987 by employing Laspeyres Divisia Indices.

¹ Thus far, the energy prices including electricity, natural gas and fossil fuel have been fully regulated by the government. The Indonesian government oversees the price of fossil fuel products with adjusting periodically following a formula in which the international price plays an important variable.

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Table 1 Fossil fuel subsidy reforms since 2005

Year	Fuel Type	Fuel price policy reform
2005	Diesel and gasoline	Manufacturing industries are no longer able to get subsidized diesel. In March, the price increased by 29% and further increased in October by 114%.
2006	LPG	LPG price increase targeted to manufacturing industries
2007	Kerosene and LPG	In order to encourage LPG use, the government introduce the kerosene to LPG conversion program
2009	Diesel and gasoline	In January, Diesel and gasoline decreased by 7% and 11%, respectively.
2013	Diesel and gasoline	Both diesel and gasoline are increased by around 40%
2013	Electricity	Electricity base tariff increased by 15%
2014	Diesel and gasoline	Both Diesel and gasoline are increased by 36% and 31%, respectively
2015	Diesel and gasoline	Gasoline subsidies are removed and diesel subsidies are reduced by Rp 1,000/ litre.

Rp = Rupiah, Kg = kilogram, LPG = liquefied petroleum gas.
Source: [5-6].

Their study observed that shifting to more energy intensive transport mode and increasing passenger-kilometres has become the main reason for the increase in energy use.

As the economic theory forecasts that a higher price will affect in decreasing consumption. Thus, an increase in fuel price is considered in this paper as a factor affecting the changes in energy intensity. In [12-13] is argued that reducing the energy price will decrease energy intensity and lead to an improvement in energy efficiency. Additionally, by employing firm level data, in [14] is demonstrated that a rise in different type of energy products ameliorate energy efficiency. Furthermore, a strong evidence of energy savings, resulting from a higher energy price in China's paper industry, is revealed in [15], as well. Increases in the energy price result in decreasing energy intensity by means of efficient usage and structural adjustment, [16-17].

Nevertheless, there are contrasting points of view regarding the influence of price on energy intensity. By employing provincial level data, in [17] is suggested that energy price had a lesser effect on energy efficiency. Further, authors of [18] investigated at China's provincial level and revealed that the role of energy price to energy intensity is weak compared to other factors.

Other research also reveals some drawbacks of high subsidies that lead to inefficiency and failure in providing an affordable energy price for the poor. In [19-21] is observed that the high subsidized energy prices are more benefitting the non-poor households rather than the poor. Further, author of [22] argued the needs of reducing the cross-subsidies of electricity rates in India that less are optimal for several consumer groups. With regard to the high subsidies of energy in Indonesia in the previous few decades, the influence of energy subsidy to the overall trend of energy intensity in the transport sector is essential as one of the factors that will be measured in this study.

Besides those studies, other researches also relate the drawbacks of transportation mobility to the environment. In [23] are investigated changes of the Green House Gases (GHG) level from the electric mobility implementation and found varies impact in different countries. Furthermore, the impact of the road traffic on the environment is observed

in [24] and importance of information and education in reducing the negative impacts of transport is emphasized. Authors of [25] have focused on road freight transport and the GHG emissions and concluded that biofuels are more favourable compare to fossil fuels. Another study from [26] also investigated the advantages and disadvantages of electromobility in the freight transport and suggested the importance of transport policy implementation in EU countries.

3 Methodology

This study investigates the driving forces of and examines the transportation energy consumption trend for, Indonesia by applying the Log Mean Divisia Index (LMDI) method for period 2000 to 2016. The transportation energy consumption is classified as passenger transportation, covering the four modes: road, water, rail and air. To determine changes in energy intensity trends, the following approach is employed [27]:

$$I_t = \frac{E_t}{Y_t} = \sum_{k=1}^n \frac{Y_{kt}}{Y_t} \frac{E_{kt}}{Y_{kt}} = \sum_{k=1}^n S_{kt} I_{kt}, \quad (1)$$

where:

I_t is the aggregate energy intensity at time t,

E_t is the energy consumption in all transport sectors at time t,

Y_t is the economic activity of all transport sectors at time t,

Y_{kt} is the economic activity in sector k at time t,

E_{kt} is the energy consumption in sector k at time t,

I_{kt} is the energy intensity of sector k at time t,

S_{kt} is the share of sector k in economic value of all transport sectors at time t.

Using multiplicative decomposition, the relation of the two time periods are described as below:

$$D_{Tot,T} = \frac{T_T}{I_0} = D_{Int,T} \times D_{Str,T}, \quad (2)$$

Table 2 Variables in the transport sector

Subsector	Mode of transport	Structural factors	Intensity factors
Passenger	Road	Share of total passenger kilometre	Energy per passenger kilometre ²
	Rail		
	Water		
	Air		

where:

$D_{Str,T}$ is the structural effect at time T (an index that determines the effect of the structural shift),

$D_{Int,T}$ is the intensity effect at time T (an index that determines the changes in sectoral energy intensity effect), which are computed as:

$$D_{Str} = \exp \left\{ \sum_{k=1}^N \frac{L \frac{E_{k,T} E_{k,O}}{E_T E_O}}{\sum_k L \frac{E_{k,T} E_{k,O}}{E_T E_O}} \ln \left(\frac{S_{k,T}}{S_{k,O}} \right) \right\}, \quad (3)$$

and

$$D_{Int} = \exp \left\{ \sum_{k=1}^N \frac{L \frac{E_{k,T} E_{k,O}}{E_T E_O}}{\sum_k L \frac{E_{k,T} E_{k,O}}{E_T E_O}} \ln \left(\frac{I_{k,T}}{I_{k,O}} \right) \right\}. \quad (4)$$

Energy intensity for passenger transport was computed separately in this study, to compare the energy efficiency improvement in each type of transport mode. The structural and intensity effects are the two driving forces that are attributed for the changes in aggregate energy in transportation. The energy intensity effect is a ratio that relates to energy consumption and turnover, which represents the energy efficiency of transportation activity. This effect is predicted to decrease over time, owing to development of more energy efficient technologies. In addition, the structural effect captures the change of turnover for each transport mode. This effect measures changes of energy use in due to the changes in modes of transports share of the economy. All the things being equal, the changes in the level of transportation turnover modal shares directly affect the level of transportation energy consumption modal share.

4 Data

Due to the lack of energy statistical data in the transportation sector in Indonesia, this study only takes into account the four modes of transport: road, water, rail and air. The data for this study comes from a peer-reviewed database of transport data: The Transport Databank [28]. This data is a collaboration of the Asian Development Bank (ADB), the Clean Air Asia's Transport Research Laboratory, University of California Davis' Institute of Transportation Studies and the Partnership of Sustainable, Low Carbon Transport (SLoCaT). The collaboration published a database on transport with a focus on Asia and the Pacific.

The historical data was constructed from national surveys and international statistics [28]. Table 2 below describes the variables in the passenger transport sector in this study.

In terms of moving passengers, this study measured activity by the passenger-kilometre (PKM). The PKM measures efficiency of the passenger transport by calculating how much energy is needed to move one passenger per kilometre. The energy consumption for passenger transport is measured in Kilo Ton of Oil Equivalent (KTOE). Changes in energy consumption are decomposed in terms of the structural effect and intensity effect using the relative contribution of the passenger tasks. This study separates the analysis of passenger and freight sectors differently as the underlying economic factors shaping for both sectors differed [29].

5 Analysis of energy consumption in the transportation sector

As increasing energy consumption aligns with economic growth, which is defined as the GDP per capita [30], it is worth comparing the transport energy use and GDP. Figure 1 shows the increasing trend both in GDP and transport energy consumption in Indonesia from 2000 to 2016. Thus, in general, as the GDP and energy use increase, it can be assumed that it will be aligned with increasing mobility and improved standard of living. Turnover in the passenger transport is influenced by several factors, for instance, population growth, urbanization and changes in income, where these factors are expected to change the level of energy consumption in the transport sector [31-32].

While the value added data are available for total transport, the data for road passenger transport is not available separately. Given that this variable is important (each providing about half of energy use in transport by 2015) but also so distinctive, this study analyzes it separately, using dominators for the energy intensity measures (passenger kilometres), for the period 2000 to 2016.

5.1 The passenger transport

In passenger transport, the aggregate turnover and aggregate energy consumption have grown approximately four-fold from 2000 to 2016, generated substantially by an increase in the distance travelled per passenger [33]. The

² A passenger kilometre is defined as one passenger being moved one kilometre.

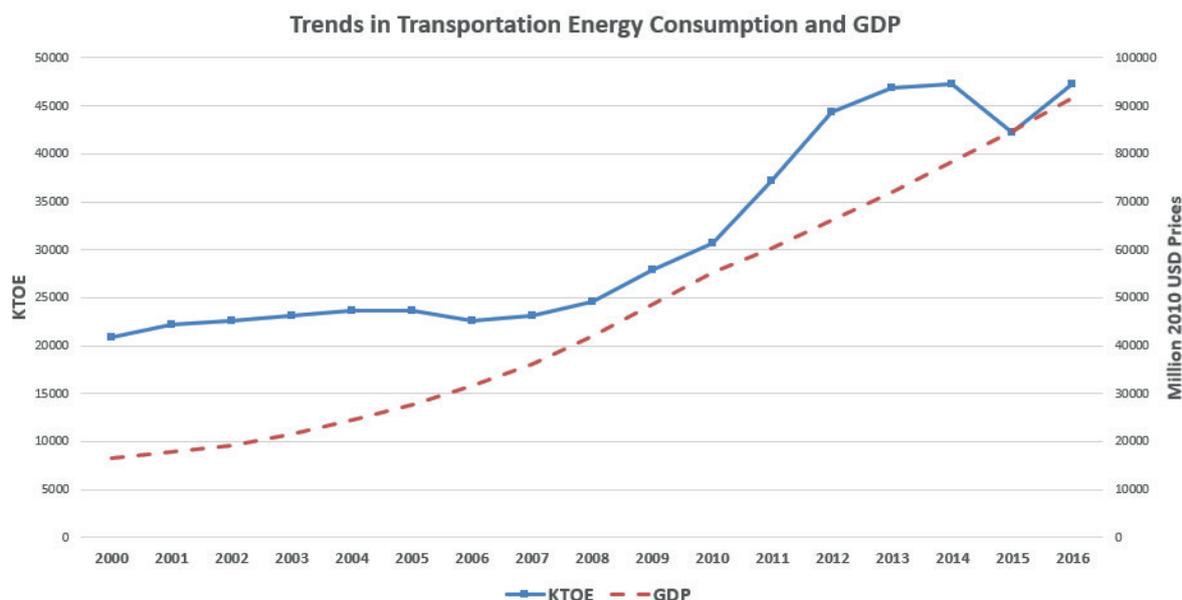


Figure 1 Trends in the transportation energy consumption and GDP

Table 3 Share and Growth of Turnover (Passenger Transport - PKM)

Sectors	Annual Growth Rate of Passenger Turnover (%)					Share of Total (%)				
	00-05	05-08	08-14	14-16	00-16	00	05	08	14	16
Road	11.6	21.6	5.4	4.8	10.1	94.6	95.4	96.4	95.7	95.6
Rail	-5.7	7.7	-0.3	1.1	-0.4	2.7	1.2	0.8	0.6	0.5
Water	0.5	8.3	8.1	5.8	5.4	0.5	0.3	0.2	0.2	0.3
Air	19.5	13.1	11.2	5.4	13.3	2.2	3.2	2.6	3.5	3.6
Aggregate	11.4	21.2	5.5	4.8	10.1					

passenger transport turnover increased from 710 billion PKM in 2000 to 3,286 billion PKM in 2016, with an average annual growth rate of 10.1%. For the same period, the total energy consumption in the passenger transport increased from 12,957 KTOE in 2000 to 54,384 KTOE in 2016 with an average annual growth rate of 9.4%. It is apparent that the increasing energy consumption growth and its turnover tracked each other very closely, with average yearly growth rates of 9.38% and 10.05%, respectively. This growth illustrates that Indonesia's transportation sector experienced an increasing energy usage and steady development, driven by many forces, including economic growth and improved standard of living.

The largest turnover share in the passenger transportation sector came from the road transport with approximately around 95.6% of the aggregate turnover in the passenger transportation sector in 2016 (see Table 3). Following the road transport, the air, rail and water transport accounted for around 3.6%, 0.5%, and 0.3%, respectively. It is not surprising that the road transport has the largest share given the vast development of Indonesia's highway networks over the last decade.

The road transport has quite a steady turnover share from around 94.6% in 2000 to about 95.6% in 2016. The turnover share of the rail and water modes decreased quite significantly during the study period from around 2.7% and

0.5% in 2000 to 0.5% and 0.3% in 2016, respectively. The turnover in the air transport increased from around 2.2% in 2000 to about 3.6% in 2016. The change in the air travel activity suggests that travellers are increasingly choosing to fly rather than to use other modes of transport. Domestic aviation was the fastest growing mode of the passenger transport, increasing by around 19% per year from 2000 to 2005 and approximately 13% annually from 2000 to 2016. Activity in other modes of the passenger transport also expanded, except for the rail transport mode that had the lowest growth over the period. Indeed, the rail transport significantly slowed its growth during the study period.

For a closer look at the structural proportion of energy consumption in the passenger transport, Table 4 illustrates the energy consumption of passenger transportation from 2000 to 2016. The road transport was the highest energy-consuming sector, responsible for around 91.8% of that consumed by the total passenger transport in 2000 but decreasing to around 88% in 2016. The share of the water transport and railway energy consumption decreased from 0.9% in 2000 to 0.5% and 0.2% in 2016, respectively, while the share of civil aviation almost doubled from approximately 6.4% in 2000 to 11.4% in 2016.

The primary reason for changes in the transport sector energy consumption and turnover is the shift in use of different modes of transport. This shift occurred as

Table 4 Share and Growth of Energy Consumption

Sectors	Annual Growth Rate of Passenger Energy Consumption (%)					Share of Total (%)				
	00-05	05-08	08-14	14-16	00-16	00	05	08	14	16
Road	10.3	19.2	4.9	4.7	9.1	91.8	89.7	91.1	88.1	88.0
Rail	-6.3	7.0	0.0	2.4	-0.5	0.9	0.4	0.3	0.2	0.2
Water	-0.9	8.4	8.3	9.3	5.4	0.9	0.5	0.4	0.5	0.5
Air	19.5	13.3	11.1	5.4	13.3	6.4	9.4	8.2	11.2	11.4
Aggregate	10.8	18.6	5.5	4.8	9.4					

Table 5 Energy intensity in passenger transport sector

Sectors	Passenger Energy Intensity (KTOE/ Billion Passenger Kilometre)					Energy Intensity Changes (%)
	00	05	08	14	16	00 - 16
Road	17.7	16.7	15.7	15.2	15.2	-14.0
Rail	6.0	5.9	5.7	5.8	6.0	-1.0
Water	31.9	29.6	29.7	30.0	31.9	-0.2
Air	52.9	52.9	53.1	52.9	52.9	-0.1
Aggregate	18.2	17.7	16.6	16.5	16.6	-9.3

changes from less intensive energy consumption mode, for instance, the railway transport, to more intensive energy consumption modes the road and air transport.

Table 5 shows the energy intensity of each transport mode in 2000, 2005, 2008, 2014 and 2016. From 2000 to 2016, the aggregate energy intensity in the passenger transport sector decreased by around 9.3%. The declining trend in this period was mainly driven by the declining trend of energy intensity in the road transport for about 14%, followed by the rail, water and air transport sector for approximately 1%, 0.2% and 0.1%, respectively.

Overall, the energy intensity of the passenger transport sector declined steadily over the period from 2000 to 2016. In Table 5 can be seen that the least efficient transport mode or the highest energy intensity in the passenger transport is civil aviation, followed by the water transport with road and rail transport in the third and fourth place. The aviation sector is the least efficient mode, as it requires around 53 KTOE per billion passenger kilometres, accounting to nearly three times more than that by the road transport and almost nine times with respect to the railway. The most efficient transport mode in passenger transport is railway, which requires only around six KTOE per billion passenger kilometres.

6 Decomposition analysis

The final energy use in the passenger transport sector rose during the study period. From 2000 to 2016, the energy intensity in the passenger transport declined from approximately 18.2 KTOE/billion tonne PKM in 2000 to 16.5 KTOE/billion PKM in 2016 (decreasing around 9.3%). By employing the LMDI method, this study estimates the driving forces of the passenger transport-related energy

consumption in Indonesia, including the structural effect (DSTR) and intensity effect (DINT). As the energy source for the transportation sector mainly comes from oil and oil products, the decomposition analysis is divided into several sub-periods following the rising of the oil price in Indonesia. During the study period, the fuel price had been increased periodically. Diesel price was increased twofold in 2005, while in 2008 both diesel and petrol were raised³ by one-third [4]. In 2013, the Indonesian government further increased diesel and petrol prices by 22% and 44%, respectively. Further, in November 2014, petrol and diesel were again increased by 31% and 36%, respectively.

Results of decomposition for the passenger transport in Indonesia from 2000 to 2016 are presented in graphical form in Figure 2.

The decomposition results in the passenger transport in Figure 2 show that the transportation energy intensity effect (DINT) significantly contributed directly to reduce the aggregate energy intensity (DTOT), while the role of the structure effect (DSTR) is found to be relatively small in most sub-periods. The energy intensity effect contributes strongly in decreasing the total energy intensity in the passenger transport. From 2000 to 2016, this effect induced a decrease in the passenger transport energy intensity for around 13%, while the structural effect increased the energy intensity for only 4%. The structural effect has had a negative effect on energy intensity in the passenger transport sector over this period. Overall, between 2000 to 2016, the aggregate energy intensity (DTOT) in the passenger transport decreased by around 9% as compared to its base level in 2000.

³ In 2005, premium gasoline has been raised from Rp 1800 to Rp 4500 /litre and kerosene from Rp 700 to Rp 2000 /litre. Further, in 2008, premium gasoline has been raised from Rp 4500 to Rp 6000 /litre and kerosene from Rp 2000 to 2500 /litre.

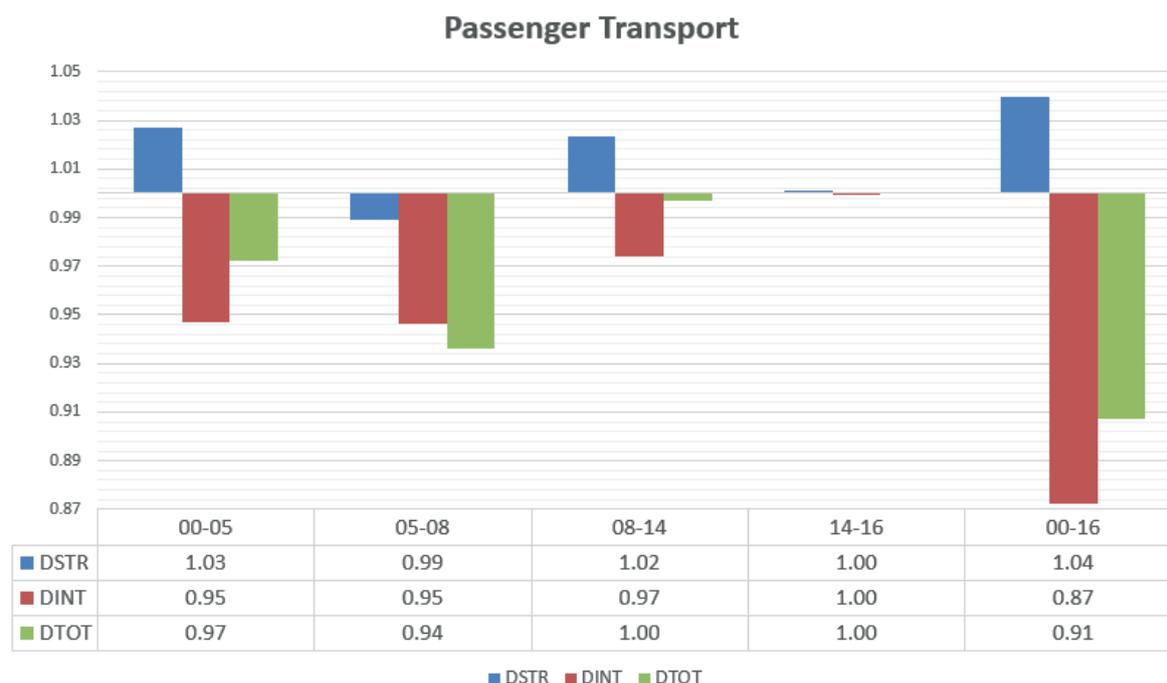


Figure 2 Decomposition result of the passenger transport

From 2005 to 2008, the structural effect contributed an 1% reduction in the energy intensity, while the intensity effect decreased it by around 5%. Overall, the aggregate energy intensity in the passenger transport decreased by around 6% during this period. In the period of 2008 to 2014, the aggregate energy intensity in the passenger transport was stable, due to the increase in the structural effect that was offset by the intensity effect.

The graph reveals that the energy efficiency in the passenger transport improved over the period from 2000 to 2016. This means that improving the transport intensity effect can significantly influence energy savings. This effect may relate to policy measures that have been enacted in Indonesia such as developing new green vehicle technology, improvement in fuel quality, advances in the transportation system and promoting energy alternatives, while, on the other hand, the increases in the structural effect potentially due to modal shifting, from less energy intensive mode, like rail transport, to more energy intensive modes such as the air and road transport. As noted earlier, the road transport sector has been a prominent transportation mode.

7 Benchmarking Indonesia to other ASEAN countries

This study provides an analysis of Indonesia's energy use compared to other selected ASEAN countries from 2000 to 2016. Due to a limit in the available data, in this study, the group of six ASEAN countries includes Indonesia, Malaysia, the Philippines, Thailand, Cambodia and Myanmar.

Figure 3 illustrates the passenger turnover share for the six selected ASEAN countries. The road transport

has the largest share in the passenger transportation over the study period in all of the six selected ASEAN countries. From 2000 to 2016 this mode of transport contributes for more than 70% of the share for Malaysia, Thailand, the Philippines, Myanmar and Cambodia, where in Indonesia this mode contributed for more than 90%. The second highest turnover contributor came from the air transport. In Cambodia, air transport almost doubled from 14.7% in 2000 to around 28.6% in 2016, where the increase of aviation was followed with a decrease of the road transport. Another significant increase in the air transport can also be seen in Malaysia, where this sector contributed for around 26.3% in 2016. The rail transport has quite a significant share in Myanmar for around 16.5% in 2000 but fell to around 3.4% in 2016. The water transport in the total turnover was found the lowest in all of the six ASEAN countries for less than 1%, although in Cambodia it increased to around 4.4% in 2016.

Similarly, to the share of turnover, the energy consumption in the road transport mode also played a key role in the overall energy consumption in the passenger transport from 2000 to 2016 (Figure 4).

This mode of transport consumed more than 70% in all the six ASEAN countries, except Cambodia, where its energy consumption share decreased for almost a half from 63.9% in 2000 to 35.9% in 2016. The share of energy consumption in air transport increased quite significantly in Malaysia, Thailand, Philippines, Cambodia and Indonesia which increased from 27.4%, 20.3%, 15.1%, 36.1%, 6.4% to around 35.7%, 28.7%, 30.6%, 58.4%, 11.4%, respectively. Similar to the share of turnover, the share of energy consumption in railways and waterways were found to be insignificant in all of

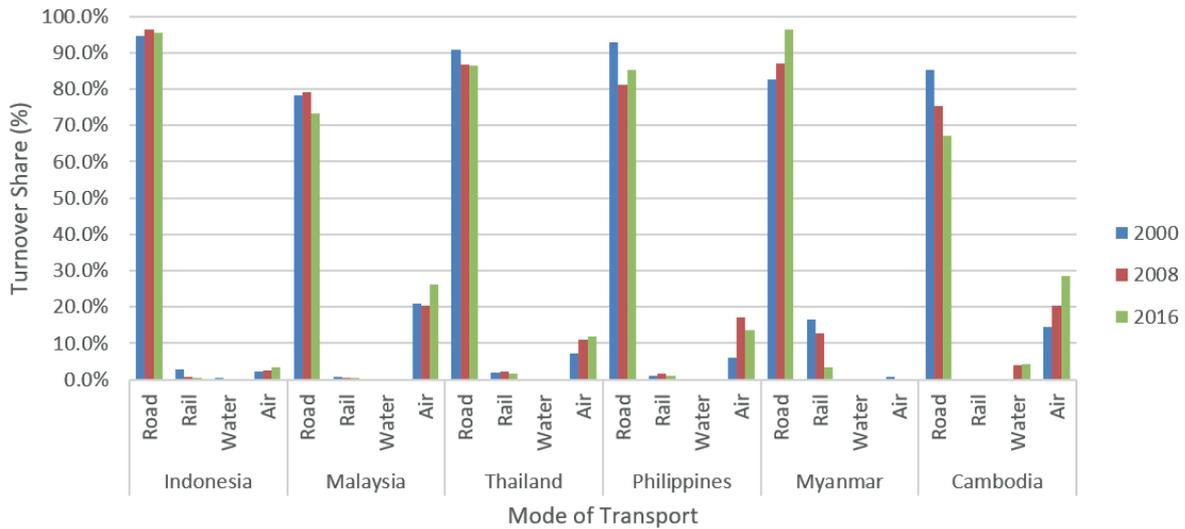


Figure 3 The passenger turnover share in ASEAN countries

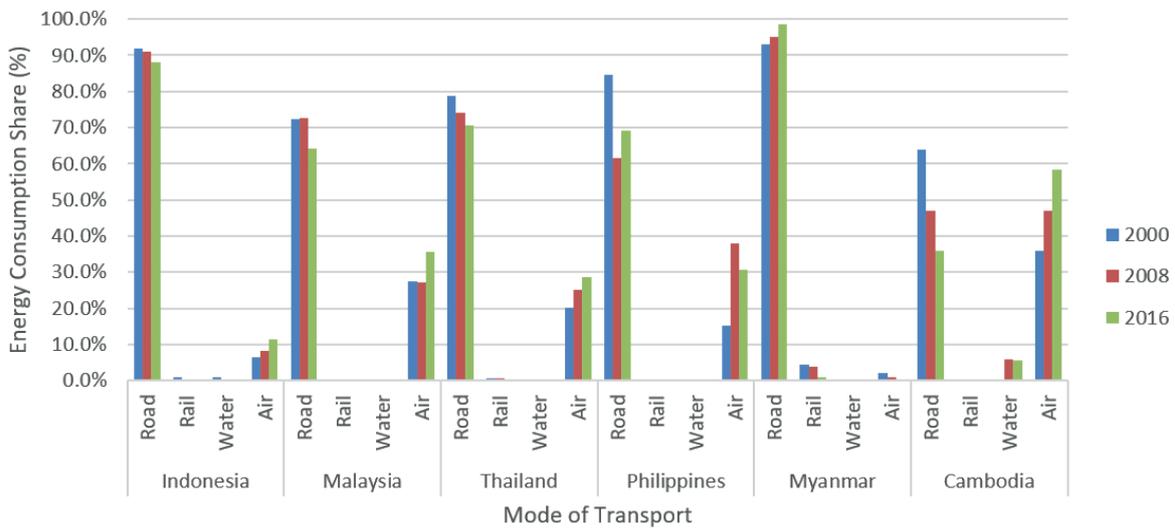


Figure 4 The passenger energy consumption share in ASEAN countries

the six ASEAN countries, which only covered less than 6% during the study period.

8 Conclusions

Regarding the turnover and energy use, the passenger transport in Indonesia experienced a substantial growth. The main factors affecting this trend were changes in the energy intensity, transport choices and turnover growth. For the passenger transport, the highest energy consuming mode and the major transport mode was the road transport. In spite of being a country with many archipelagos, the road transport contributed the largest turnover in passenger transport, whereas air, waterways and rail transport did not play a significant role in the passenger transportation in Indonesia. Over the study period from 2000 to 2016, the road transport accounted for the largest share, with more

than 90% of the share in terms of passenger-kilometres travelled.

In the passenger transport, the structural effect (DSTR) had an increasing impact on the aggregate energy intensity in most years, although its magnitude was insignificant compared to the decreasing intensity effect. The increasing structural effect was associated with the modal shifting, from the less intensive energy modes, like railway, to more energy consumption modes, like road and aviation. In the passenger transport (see Table 3), the share of railways to total turnover dropped from 2.7% in 2000 to 0.5% in 2016; the air transport increased from 2.2% in 2000 to 3.6% in 2016; while the road transport increased only slightly by around 1% in 2016 compared to the base year. Based on [33], the increasing demand of the air transport services in Indonesia recently has been encouraged by the substantial development of airways transport infrastructure, specifically airports and the growing of the low-cost airlines. Between

2015 and 2016, the total number of airline passengers grew 10.5%, to 95.2 million [33]. In line with the increasing turnover share in the aviation, the ratio of the air transport energy consumption to other modes also increased from around 6.4% in 2000 to approximately 11.4% in 2016. Moreover, the energy consumption in the road transport decreased from 91.8% in 2000 to 88% in 2016; while the rail and water transport also had a slight decrease in energy consumption (see Table 4). The road transport has been the prominent transportation mode, which explains more than 90% of the total turnover and total energy consumption during the study period.

Over the period 2000 to 2016, the energy intensity of the passenger transport sector declined steadily. In the passenger transport, the decreasing aggregate energy intensity was attributable to the intensity effect that lowered the overall energy intensity in the passenger transport to around 9% from 2000 to 2016. Further, the findings also indicate that the transportation energy intensity effect had a greater contribution in reducing overall energy intensity in the passenger transport; while the role of the structural effect increased the aggregate energy intensity. The reduction of the intensity effect can be associated with better and more effective policy measures, for instance encouraging the use of cleaner fuels, upgrading the traffic equipment and supporting development of the new technology. In addition, since the fuel price reform, Indonesia's energy prices have increased substantially, although it is lower than international fuel prices. Therefore, energy price changes potentially have had a small impact on the overall energy intensity changes in the transport sector.

9 Policy implications

Several features of Indonesia's transport system are distinctive in an international context. Almost all the passenger kilometres are travelled on roads (95.6% in 2016), with virtually no rail (0.5%) or water (0.3%) passenger travel, but with a small but rising share of air travel (3.6% in 2016). A good transportation system is one of the main components for strong economic growth [34]. However, energy consumption in this sector has grown continuously over the last decade and will potentially continue to increase in the future. Attempts to reduce the energy use in the transportation sector require significant attention, where the clear and coherent government policy needs to be established to conduct a suitable energy policy in this

sector. Therefore, the findings in this study are aimed to establish a scientific evidence for developing a policy on energy efficiency measures in the transportation sector.

The structural effect of the passenger transport indicated a negative influence (that is, increasing) aggregate energy intensity over the period of the study. This seemingly indicates contradictory efforts in reducing overall energy intensity. Based on the observation of energy usage performance across the transportation modes in the study period, the breakdown of the road and air transport turnover for passenger has increased substantially, employing more energy per unit of turnover compared to other modes of transport. Therefore, to lower the level of energy use in the transport sector, one of the key policy measures required is to promote different modes of transport besides the road and air transport, such as railways, waterways transport and other modes of transport that consume less energy.

The road transportation system is a crucial sector that not only moves people and goods, but is also essential for industry and local trade. Therefore, the key strategy to further reduce the energy intensity growth in the transport sector is to lower the growth of energy consumption. Enacting green energy policies, such as shifting to cleaner energy fuels [35] and encouraging the use of public transport [36], including the rail and water transportation would help to reach this goal. Regulatory measures, including vehicle efficiency and occupancy standards [37] are needed to reduce the energy intensity in the transport sector. Moreover, fiscal measures, such as providing tax incentives and subsidies for development of the public transportation [36], cleaner fuels or development of green technology could be considered as an effective way to encourage awareness of the people to use energy more efficiently that leads towards a modal shifting to more energy efficient transport modes.

Overall, Indonesia's transport structure needs to be focused on the waterway and railway transports that have lower energy use and greater transport capacity. The Indonesian Government needs to enact various policy measures to expand investment in the waterways and railways. Improving development of the inland waterways and railways network can be done gradually by providing more effort in optimizing networks across different transport modes and enhancing the road infrastructure to make all the other transport modes closely connected [38]. These efforts are expected to create an efficient transport system, where railways and waterways become more dominant in the Indonesia's transport system.

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