



SUSTAINABLE LAND TRANSPORT INDICATORS ON ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSIONS IN ASEAN GUIDELINES



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**Sustainable Land Transport Indicators on
Energy Efficiency and Greenhouse Gas
Emissions in ASEAN**

Guidelines

The ASEAN Secretariat
Jakarta

The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967. The Member States of the Association are Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. The ASEAN Secretariat is based in Jakarta, Indonesia.

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List of abbreviations

2DS	Two-degree scenario
5EAP	Fifth Environmental Action Programme (of the European Union)
ADB	Asian Development Bank
AJTP	ASEAN-Japan Transport Partnership
AMS	ASEAN Member States
ACE	ASEAN Centre for Energy
AJOA	ASEAN-Japan Transport Information Project
ASEAN	Association of Southeast Asian Nations
ASIF	Activity-Structure-Intensity-Factor of Emissions Framework
BAU	Business-as-usual
BITRE	Bureau of Infrastructure, Transport, and Regional Economics
BUR	Biennial Update Report to the United Nations Framework Convention on Climate Change
CAPs	Concentrated ambient particles
CH ₄	Methane
CO	Carbon monoxide
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
COP	Conference of parties (to the United Nations Framework Convention on Climate Change)
DPSIR	Driver – Pressure – State – Impact – Response framework
EEA	European Environmental Agency
EC	European Commission
EGSLT	Expert Group on Sustainable Land Transport
EST	Environmentally Sustainable Transport
EU	European Union
GDP	Gross domestic product
GFEI	Global Fuel Economy Initiative
Gg	Gigagramme
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global positioning system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HFT	Heavy freight truck
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ITF	International Transport Forum
ITPS	Institute for Transport Policy Studies
Kg	Kilogramme
KLTPSP	Kuala Lumpur Transport Strategic Plan
Km	Kilometre
LCV	Light commercial vehicle
LGE	Litres of gasoline equivalent
LTWG	Land Transport Working Group
MEET	Ministerial Conference on Global Environment and Energy in Transport

MFT	Medium freight truck
MTWG	Maritime Transport Working Group
NCBI	National Centre for Biotechnology Information
NDC	Nationally-determined contributions
N ₂ O	Nitrous oxide
NO ₂	Nitrogen dioxide
NO _x	Nitrogen oxide
O ₃	Ozone
ODI	Overseas Development Institute
OEB	Overall energy balance
OECD	Organization for Economic Co-operation and Development
PPMC	Paris Process on Mobility and Climate
PKM	Passenger kilometres
PM	Particulate matter
SDG	Sustainable development goals
SLoCaT	Partnership on Sustainable, Low Carbon Transport
SO ₂	Sulphur dioxide
TEEMP	Transport emissions evaluation model for projects
TERM	Transport and Environment Reporting Mechanisms
TFWG	Transport facilitation working group
TJ	Terajoule
TKM	Tonne kilometre
TSP	Total suspended particulates
UN	United Nations
UNCRD	United Nations Commission on Regional Development
UNDESA	United Nations Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
USD	U.S. dollars
WHO	World Health Organization
VOC	Volatile organic compounds
VKM	Vehicle kilometre
VMT	Vehicle miles travelled
*	Multiplication

Preface

This document, the Sustainable Land Transport Indicators on Energy Efficiency and GHG Emissions in the ASEAN – Guidelines, builds on the ASEAN Kuala Lumpur Strategic Plan 2016-2025 and implement its Sustainable Transport (ST) milestone ST-2.3 on the development of a monitoring framework and harmonised approach for indicators on energy and GHG emissions in the transport sector.

It was developed during a two-year process (from October 2016 to November 2018) led by the Expert Group on Sustainable Land Transport and through the facilitation of the ASEAN Secretariat and guided by the ASEAN Land Transport Working Group and adopted by the ASEAN Transport Ministers. It was supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit through the project titled Energy Efficiency and Climate Change Mitigation in the Land Transport Sector in the ASEAN Region. Accompanying these Guidelines is a background report which was published in November 2016. This report gives more detailed information about the background and the process of defining and suggesting indicators for ASEAN.

The primary target group of the Guidelines are technical staff, as well as decision makers who are involved in generating and utilising land transport data, particularly in relation to energy and environmental contexts. In many ASEAN Member States, the responsibilities for achieving more sustainable pathways for land transport, energy, and the environment fall under various government agencies: Therefore, these Guidelines aim to be useful for a wide range of institutions.

In addition to targeting government stakeholders, these Guidelines intend to serve as a catalyst for engaging relevant stakeholders from academia, industry, and civil society. It not only addresses experts but can also be used to elevate general interest regarding transport and its implications for energy and the environment. This document will also be useful in facilitating future discussions on sustainable land transport indicators within the AMSs as well as at the regional level. Within these debates, discussions regarding best practices, identification of common challenges, and regional approaches to addressing such, can benefit the AMSs.

While these Guidelines provide a basis by which sustainable land transport indicators can be defined and adopted by ASEAN as a region, each Member State still has the option to select the most appropriate indicators and future actions. The technical content and guidance mentioned in this document are to be considered for further development and actions by ASEAN and its Member States.

Executive summary

The Sustainable Land Transport Indicators on Energy Efficiency and GHG Emissions in ASEAN – Guidelines (hereinafter ‘Guidelines’) aims to support the harmonisation across ASEAN of the monitoring of land transport indicators, with a certain focus on energy efficiency and greenhouse gas emissions. This document was developed in accordance with the Sustainable Transport (ST) milestone ST-2.3 of the ASEAN Kuala Lumpur Transport Strategic Plan: ‘the development of a monitoring framework and harmonised approach for indicators on energy and greenhouse gas (GHG) emissions in the transport sector.’ It presents indicators as variables meant to accurately represent the sustainability aspects of land transport. Such indicators are critical in informing policy and investment decisions by enabling performance tracking throughout time, and by enabling a better understanding of the underlying factors that impact such performance. These Guidelines provide technical information and practical insights related to the generation of data for the calculation, reporting, and interpretation of such indicators.

Chapter 1 introduces the Guidelines by discussing their scope and by providing pointers for reading the document effectively, so that it can be used for transforming data into useful information in the form of indicators, which can then in turn be used towards guiding relevant policy decisions.

Chapter 2 establishes the importance of providing attention to the transport sector in the ASEAN region to effectively mitigate greenhouse gas emissions, as set out in the KLTSP. This should also be aligned with the other international frameworks that require sound data and harmonised approaches, such as the 2030 Agenda for Sustainable Development. The chapter also discusses regional-level recognition of the importance of transport data and indicators relevant to ASEAN and its Member States.

Chapter 3 discusses examples of regional-level transport indicator initiatives that have been implemented, and the important lessons learned.

Chapter 4 gives an overview of the priority indicators included in these Guidelines, as well as explaining the format of the indicator factsheets at the end of the document. It also discusses the key principles and theoretical framework that guided the participatory process of selecting the priority indicators. The Guidelines highlight the importance of utilising a bottom-up indicator approach that recognises the interlinkages of parameters within a system. The Guidelines also recognise that a graduated or tiered approach may be better suited for ASEAN Member States to generate more robust data in the future, and at the same time utilise the best currently available data.

The factsheets provide both technical and practical information regarding the indicators. They contain commonly used descriptions, units, data collection, and calculation methodologies,

as well as the expected range of values for each indicator. They also provide practical insights relating to the interpretation of the indicators themselves, highlighting their limitations and strengths, as well as the relationships between them.

While this document provides a basis by which sustainable land transport indicators can be defined and adopted by ASEAN as a region, it mainly provides guidance and does not bind ASEAN or its Member States to report the data. It recognises that the indicators mentioned in this document are to be considered for further development and actions by ASEAN and its Member States. At the same time, the Guidelines aim to encourage ASEAN and its Member States to move towards a harmonisation of their approach to monitoring the progress of sustainable transport.

1. Introduction

1.1. Background

Transportation is an essential cornerstone of development, as it enables physical transactions between people, and provides access to services, opportunities, and goods. Economic progress leads to increased demands for travel, which in turn may result in negative impacts such as the increased consumption of fossil fuels, air pollution, congestion, crashes, and greenhouse gas emissions (GHGs). Such trends are becoming more prominent in the ASEAN (Association of Southeast Asian Nations) region, which as a bloc already has the second-largest road vehicle fleet in Asia. Moving towards more sustainable transportation pathways and effectively addressing the negative impacts of transportation hinge on effective monitoring. Enabling the generation of appropriate and robust indicators is key to moving towards effective policy making, particularly in transport.

The existence of regional cooperation mechanisms such as ASEAN provides opportunities for collaboration towards the provision of a common framework for generating and reporting highly relevant transportation data and indicators. This has been recognised in the Kuala Lumpur Transport Strategic Plan (2016-2025) (KLTSPP), which has established a strategic goal that emphasises the importance of instituting a harmonised approach for sustainable transport indicators (ASEAN, 2016):

‘Formulate a regional policy framework to support sustainable transport which includes low carbon modes of transport, energy efficiency and user-friendly transport initiatives, integration of transport and land use planning’.

In support of this strategic goal, the KLTSPP has prioritised ‘the development of a monitoring framework and harmonised approach for indicators on energy and GHG emissions in the transport sector.’

The provision of a harmonised approach for such indicators would not only be beneficial for ASEAN as a bloc, but would also support the ASEAN Member States (AMSs) in monitoring progress in meeting their own national objectives under the different related processes such as the Paris Climate Agreement, Sustainable Development Goals (SDGs) and the New Urban Agenda, as well as in benchmarking their performance with each other.

This document (hereinafter referred to as the ‘Guidelines’) provides guidance on priority sustainable transport indicators to support the thrust of ASEAN to move towards a more harmonised approach for monitoring energy and GHG emissions in the transport sector. They provide insights related to the standardisation, collection and reporting of such indicators that are relevant for pursuing initiatives that support the transport, energy, and environment nexus in the ASEAN region.

1.2. How to use the Guidelines

Resource-efficient and effective policymaking entails proper assessment of the current state of the issues that need to be addressed, clearly defined objectives, and robust performance, and impact monitoring. Such processes are dependent on the availability of appropriate indicators. Litman et al. (2008) provides a framework for reflecting the role of indicators in decision-making processes, and states that such are needed for the following: visioning or agenda setting, measurement and targets, policy formulation, policy adaptation and implementation, responses (travel patterns), physical impacts (e.g. emission and accident rates), effects these have on the people and the environment (e.g. injuries and deaths, and ecological damages) and the economic impacts (e.g. costs to society due to crashes and environmental degradation). These Guidelines aim at enabling the use of the indicators in the policy-making processes as mentioned above.



Figure 1: Indicator cycle in sustainable transport (Source: Gota, 2016)

Chapter 2 lays down the bases for pursuing regional cooperation towards better sustainable transport indicators in ASEAN. Chapter 3 introduces the indicators and discusses the considerations for their selection, as well as the structure of the indicator factsheets. At the core of these Guidelines are the indicator factsheets (Annex 1). The provision of these factsheets aims to contribute towards a common understanding of the selected indicators by providing essential information for enabling the generation of such indicators. Readers must note the following when reading this document:

- These Guidelines have been developed to include land-based transportation (road and rail), with a primary focus on road transportation, as this sub-sector is the largest consumer of energy and contributes the highest proportions of GHG and air pollutant emissions among the transportation sub-sectors in all the ASEAN Member States (see Table 1 in section 2.1). Rail transport is integrated into these Guidelines when appropriate, as determined by its relative importance in relation to the specific indicators.
- While the Guidelines focus on transport GHGs and energy efficiency-related indicators, the document recognises the importance of the other pillars of sustainable transport, and thus includes priority economic, and social (e.g. safety) indicators.
- The Guidelines also provide examples, either using ASEAN-specific values whenever possible, or values from other countries or regions, to provide proper guidance with regards to the expected ranges, particularly for the indicators that are normalised.
- The Guidelines also provide insights on potential data sources, including in-country sources, as well as credible sources of information that are related to the indicators. A review of the sources of information, particularly official ones, are highly encouraged.
- The suggested indicators in these Guidelines were based on the discussions with the representatives of the AMSs during the relevant meetings and workshops, but it is recognised that other variations of the indicators may be adopted in the future, based on future discussions. It is further emphasised that the suggested list does not represent a binding list of indicators that all AMSs have to collect, but rather gives guidance for future data collection and shall help to harmonise different approaches in the future.
- The Guidelines provide links to external resources (Annex 2) to enable a deeper understanding of the indicators. It recognises the resource limitations in the region, and provides suggested simplified approaches for estimating the indicators, whenever appropriate.
- As more complex indicators require more detailed data, the Guidelines suggest that a tiered approach is taken. This would involve a short-term focus on less complex but critical indicators, with the goal of generating more detailed indicators in the future. Monitoring systems with a multi-year action programme that improves data availability and measurement over a period are more likely to succeed in ASEAN than those with an extensive programme that aims to collect and report all the data required from the outset. Thus, it is recommended to start immediately with a minimum set of indicators based on data and resource availability, and to advance the system over time by adding additional indicators (Figure 2). It is proposed that two basic categories of indicators for monitoring impact of sustainable transport policies and strategies on energy efficiency and GHG emissions are collected (see Figure 2). Different priority categories are necessary because of the varied availability of different parameters across the ASEAN region. This tiered approach is founded on a philosophy adopted by the Intergovernmental Panel on Climate Change (IPCC) with regards to measuring emissions, as well as the United Nations Sustainable Development Goals (SDGs), which depend on the availability of data.

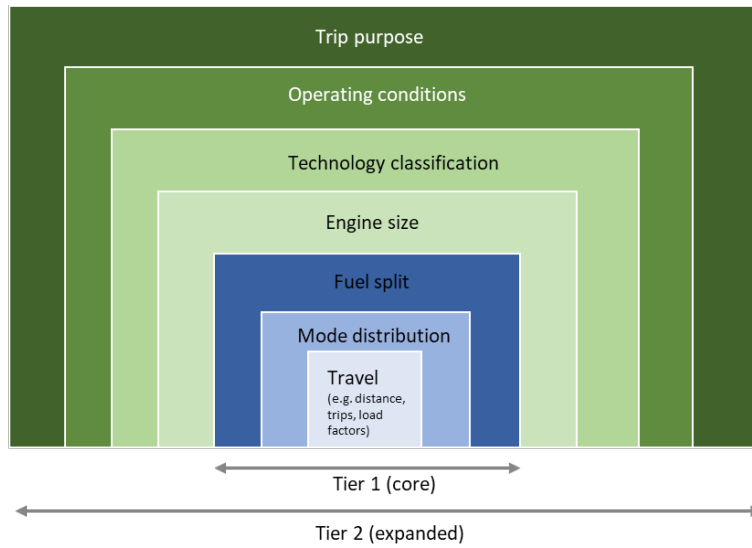


Figure 2: Energy efficiency and GHG indicator typology (Source: Gota, 2016)

- While these Guidelines provide essential information about the selected indicators as well as insights on relevant strategic options for ASEAN towards harmonised sustainable transport indicators in the region, they are not meant to be understood as a roadmap, but rather as a tool for enabling future decisions regarding transport data collection and indicator generation in the bloc.

2. Drivers for transport indicators

The transport sector has significant positive and negative impacts on the economic, environmental, and social domain. Planning and decision-making institutions therefore need tools to identify priority issues, efficiently implement policies, allocate infrastructure and prioritise investments. This chapter discusses the relevant externalities brought about by transportation, as well as the relevant global and regional initiatives that address such impacts, and how indicators play a role in these initiatives.

2.1. Greenhouse gas emissions and energy consumption

The transport sector is a significant contributor to man-made GHG emissions. An analysis by SLoCaT (2015) shows that transport consumed the most energy of any sector in 40% of the countries globally, and the second-most in the remaining countries.

GHG emissions from the transport sector is primarily a function of fossil fuel energy consumption. The transportation sector is a primary fossil-consuming sector and is estimated to account for 14% of the global GHG emissions. Various estimates suggest an economy-wide emission gap of 15-20 billion tonnes by 2030 between the business-as-usual scenario (BAU) and the 2-degree scenario (2DS) (UNEP, 2015). The global share of transport in this economy-wide emission gap (PPMC, 2015) at 2030 is between 19% and 26%. This underscores the importance of transport sector engagement in economy-wide mitigation efforts. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) highlights not only increased certainty and severity of climate change impacts, but also a higher mitigation potential for transport sector than previous assessments (IPCC, 2014).

The global situation is reflected in South-East Asia. For example, the International Energy Agency (IEA) estimates that transportation accounted for half of the total oil demand in South-East Asia in 2015, and will account for 53% by 2040 (IEA, 2015). The IEA also projects that oil will remain dominant as an energy source for transportation, representing more than 90% of the transport energy in 2040.

Existing evidence points to road transportation as a critical sub-sector in terms of GHG emissions. IEA (2015) estimates that road vehicles account for 28% of total energy-related CO₂ emissions, and approximately 92% of the transport-related CO₂ in South-East Asia. Table 1 below provides the latest country-level estimates of the IEA on the contribution of road transport in total transport CO₂, and total energy-related CO₂ emissions (IEA, 2016). Similar proportions were calculated by the Institution for Transport Policy Studies (ITPS) and Clean Air Asia (ITPS & CAA, 2012). Their study estimates that about 89% of the total transport-related emissions in the ASEAN region are from road transportation.

Table 1: Relative Contributions to CO₂ (Transport, and Road Transport)

	% transport vs total energy CO ₂	% road vs transport CO ₂	% road vs total energy CO ₂
Brunei Darussalam	23%	100%	23%
Lao PDR	53%	85%	45%
Indonesia	29%	88%	26%
Malaysia	28%	96%	27%
Myanmar	42%	87%	37%
Philippines	30%	86%	25%
Singapore	15%	98%	15%
Thailand	26%	95%	25%
Viet Nam	19%	97%	19%

Source: IEA (2017)

The 4th ASEAN Energy Outlook 2013-2035 states that the transportation sector represents the second-highest share in final energy consumption of the different sectors in the region (industrial sector has the highest share). With the expected continued economic growth, coupled with increasing urbanisation and limited public transportation infrastructure, transport energy consumption is estimated to grow at 4.5% per year in the Outlook's business-as-usual scenario: from 118 million tonnes of oil equivalent (Mtoe) in 2013 to 309 Mtoe in 2035 (ASEAN Centre for Energy, 2015). The share of transportation in total final energy demand in ASEAN is estimated to be around 28% in 2035.

Policies and programmes that would reduce energy intensity and greenhouse gas emissions from the sector need to be intensified, for example those that are geared towards improving public transportation and increased uptake of alternative fuels. Such policies are estimated to have the potential of yielding energy savings of 13% by 2035 against business-as-usual levels (ASEAN Centre for Energy, 2015). Effective formulation, implementation, and impact monitoring of such policies and programmes rely heavily on the availability of robust data and indicators.

2.2. Climate agreements

Climate change is one of the most important modern-day global issues. The International Panel on Climate Change (IPCC) states that the 'warming of the climate system is unequivocal' (IPCC, 2013). The acceleration of the process of global warming through human influence is clear and made evident by the increasing atmospheric concentrations of GHGs. The IPCC states that 'it is extremely likely' that human influence has affected the global water cycle, reduced the amounts of snow and ice, and caused the rise in sea levels

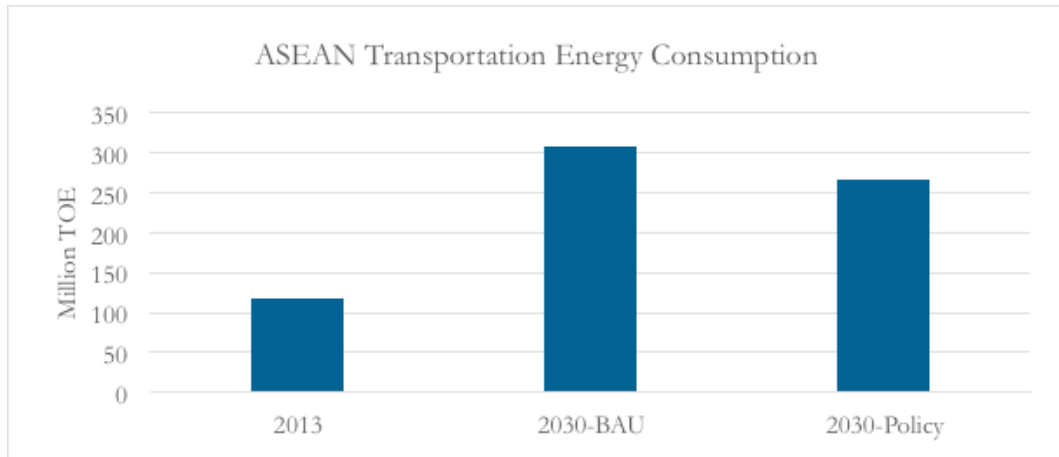


Figure 3: Energy consumption of the transportation sector in ASEAN (Source: ACE, 2015)

(IPCC, 2013).

Global mechanisms and local interventions that aim to reduce humanity's impacts on the climate are dependent on robust estimates of the amounts of GHGs emitted, as well as accurate estimates of the effectiveness of measures to mitigate emissions. The Kyoto Protocol was the first agreement to mandate country-level binding greenhouse gas emission reduction targets, involving 36 industrialised countries and the European Union. The Kyoto Protocol was adopted on 11 December 1997 and entered into force on 16 February 2005. The Protocol's first commitment period started in 2008 and ended in 2012, and the second commitment period began on 1 January 2013 and will end in 2020. At the 2015 Conference of Parties (COP) 21 in Paris, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to combat climate change and to accelerate the actions and investments needed for a sustainable low-carbon future. This was an ambitious, binding and universal agreement holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. One of the main requirements of the Paris Agreement is for all Parties to put forward their best efforts through 'nationally determined contributions' (NDCs)¹ and to strengthen these efforts in the years ahead. All Parties need to submit new NDCs every five years, with the clear expectation that they will 'represent a progression' beyond previous ones, and to report regularly on their emissions and 'progress made in implementing and achieving' their NDCs, and to undergo international review.

As of 1 November 2017, 163 NDCs have been officially submitted. The NDCs represent a unique opportunity to enhance mitigation and adaptation measures in transport and other sectors (Table 2 below provides a summary of ASEAN NDCs). Maximising national mitigation actions will require optimising contributions from transport in existing NDCs through mechanisms to increase mitigation ambition in successive evaluation periods. A review of NDCs by SLoCaT (2015) reveals that the transport sector is considered as a

¹ INDCs initially included the word 'intended' while communicating proposed mitigation and adaptation measures ahead of the Paris Agreement in COP21. However, as countries formally join the Paris Agreement, the word 'intended' is removed and an INDC is converted into a NDC.

priority mitigation sector. The analysis found that among all NDCs submitted, more than three quarters explicitly identify the transport sector as a mitigation source, and about 60% of NDCs propose transport sector mitigation measures. However, only about 10% of NDCs have established targets for transport sector emissions. Determining and implementing NDCs will ultimately require countries' better understanding of the emissions contributions of different sectors and their mitigation potential. To implement NDCs at the sectoral level, either the economy-wide targets need to be distributed to the different sectors, or the impact of actions in different sectors need to be aggregated to determine the progression towards the committed economy-wide targets. Considering the high contribution of the transport sector to economy-wide emissions, the transport sector needs to provide significant contributions that can properly be monitored.

Table 2: NDC emission reduction commitment by ASEAN Member States

Country	NDC economy-wide emission commitment	Transport share in economy-wide emissions 2010	Transport sector-specific target in NDC	Mitigation actions identified in NDC
Brunei Darussalam	Energy sector: to reduce total energy consumption by 63% by 2035 compared to BAU. Land transport sector: to reduce CO ₂ emissions from morning peak hour vehicle use by 40% by 2035 compared to BAU.	6.6%	Yes	Fuel economy improvement, e-mobility, fuel subsidy removal, intelligent transport system, land use strategy, public transport improvement, parking reform, transport plan.
Cambodia	Cambodia intends to implement conditional emission reduction activities that are expected to bring a maximum reduction of 3,100 Gg CO ₂ eq compared to baseline emissions of 11,600 Gg CO ₂ eq by 2030 (27%).	7.5%	No	Promoting mass public transport. Improving operation and maintenance of vehicles through inspection and eco-driving, and the increased use of hybrid cars, electric vehicles and bicycles.

Country	NDC economy-wide emission commitment	Transport share in economy-wide emissions 2010	Transport sector-specific target in NDC	Mitigation actions identified in NDC
Indonesia	Indonesia has identified an unconditional reduction target of 29% against 2030 BAU levels. Indonesia's aim to reduce up to 41% against 2030 levels is subject to provision of support through bilateral cooperation, covering technology development and transfer, capacity building, payment for performance mechanisms, technical cooperation and access to financial resources.	15.1%	No	No
Lao PDR	Lao PDR intends to undertake several actions to reduce its future GHG emissions, subject to the provision of international support.	13.8%	No	Public transport improvement, 10% biofuel share by 2025, and development of road infrastructure.
Malaysia	Malaysia intends to reduce its GHG as expressed by the intensity of emissions relative to GDP. It has undertaken to reduce this GHG intensity of its economy by 45% by 2030 relative to 2005. This consist of 35% on an unconditional basis and a further 10% conditional upon receipt of climate finance, technology transfer and capacity building from developed countries.	10%	No	Pursuance of green growth goals under the 11 th Malaysia Plan 2016-2020, as well as existing policies such as the biofuel policy.

Country	NDC economy-wide emission commitment	Transport share in economy-wide emissions 2010	Transport sector-specific target in NDC	Mitigation actions identified in NDC
Myanmar	Myanmar intends to undertake mitigation actions in line with its sustainable development needs, conditional on availability of international support, as its contribution to global action to reduce future emissions of greenhouse gases.	2.4%	No	Development of National Transport Master Plan and National Implementation Plan on Environmental Improvement in the Transport Sector, as well as city-focused sustainable transport options.
Philippines	The Philippines intends to undertake GHG (CO ₂ e) emissions reduction of about 70% by 2030 relative to its BAU scenario for 2000-2030.	15%	No	No
Singapore	Singapore aims to reduce the GHG emissions intensity of its economy by 36% from 2005 levels, and to stabilise its emissions with the aim of peaking around 2030.	15.5%	No	No
Thailand	Thailand intends to reduce its greenhouse gas emissions by 20% from the projected BAU level by 2030. This could increase up to 25%, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change.	15.6%	No	Public transport improvement, fuel efficiency improvement, road-to-rail shift for passenger and freight, vehicle taxation scheme as embodied in the Environmentally Sustainable Transport System Plan (2013-2030).

Country	NDC economy-wide emission commitment	Transport share in economy-wide emissions 2010	Transport sector-specific target in NDC	Mitigation actions identified in NDC
Viet Nam	With domestic resources, by 2030 Viet Nam will reduce GHG emissions by 8% compared to BAU, in which emission intensity per unit of GDP will be reduced by 20% compared to the 2010 levels. The above-mentioned 8% contribution could be increased to 25% if international support is received through bilateral and multilateral cooperation as well as through the implementation of new mechanisms under the Global Climate Agreement, in which emission intensity per unit of GDP will be reduced by a maximum of 30% compared to 2010 levels.	14.1%	No	Inspection & maintenance, decarbonising fuel, fuel quality & vehicle emission standards, fuel subsidy removal, green freight (road to rail) & public transport improvement.

Source: Based on the official NDC submissions of the countries to the UNFCCC.

2.3. Sustainable development goals and transportation

The regular and institutionalised collection, reporting and verification of priority indicators for measuring energy efficiency and transport emissions from transportation should be carried out using an approach that scrutinises transportation activity and system structure. This is important not just to take into account global updates to the climate regime, but these data are also important in the other dimensions of transport planning and evaluation, and can help address other important negative externalities brought about by transportation, such as urban air pollution, and safety issues, as discussed in Box 1 below.

Box 1: Other significant externalities of transportation

Transportation is a major source of air pollution. The incomplete reaction of carbon with oxygen can produce either carbon monoxide (CO) or carbonaceous particles, which make up particulate matter (PM). Particulate matter has been implicated as the most critical road transport sector pollutant due to its well-documented impacts on human health, the relative contribution of the transport sector to PM emissions and the proximity of the source vehicles to the human population, particularly in urban areas. Karagulian et al. (2015) reviewed more than 400 studies in 51 countries and found that approximately 25% of particulate matter with a diameter of 2.5 micrometres or less (PM_{2.5}) in urban areas is attributable to traffic. In South-East Asia, the contribution is estimated to be 36% on average.

Table 3: Transport pollutants and associated health outcomes

Health outcome	Associated transport-related pollutants
Mortality	Black smoke, ozone (O ₃), PM _{2.5}
Respiratory disease (non-allergic)	Black smoke, ozone, nitrogen dioxide (NO ₂), volatile organic compounds (VOCs), concentrated ambient particles (CAPs), diesel exhaust
Respiratory disease (allergic)	O ₃ , NO ₂ , PM, VOCs, CAPs, diesel exhaust
Cardiovascular diseases	Black smoke, CAPs
Cancer	NO ₂ , diesel exhaust
Adverse reproductive outcomes	Diesel exhaust, NO ₂ , carbon monoxide (CO), sulphur dioxide (SO ₂), total suspended particles (TSP)

Source: Adapted from Kryzanowski et al 2005 cited in Dora and Hosking (2012).

Road safety issues have also been recognised as a global concern. In fact, the Sustainable Development Goals that were agreed upon by the heads of states at the United Nations General Assembly in September 2015 include a target for the reduction of road traffic deaths of 50% by 2020. The World Health Organization (WHO) estimates that road crashes are the main cause of death among people aged 15-29 years old (WHO, 2015). Aside from fatalities, non-fatal disabilities from road crashes are also an important concern for many countries across the globe.

The 18th session of the Commission on Sustainable Development (UNDESA, 2010) in 2009 reviewed amongst others the global progress on sustainable transport. It identified lack of good quality data as an important barrier to sustainable transport and highlighted that ‘strengthening transport infrastructure and services will need enhanced transport data collection and analysis in many countries’.

The Rio+20 Summit outcome document *The Future We Want* (UNDESA, 2012), the governments highlighted ‘the importance of the efficient movement of people and goods, and access to environmentally sound, safe and affordable transportation to improve social equity, health, resilience of cities.’² They further undertook to ‘Promote the science-policy interface through inclusive, evidence-based and transparent scientific assessments, as well as access to reliable, relevant and timely data in areas related to the three dimensions of

² The United Nations Conference on Sustainable Development - or Rio+20 - took place in Rio de Janeiro, Brazil on 20-22 June 2012, 20 years after the Earth Summit in the same city brought together UN Member States to determine an agenda on sustainable development.

sustainable development, building on existing mechanisms, as appropriate; in this regard, strengthen participation of all countries in international sustainable development processes and capacity-building especially for developing countries, including in conducting their own monitoring and assessments.’

The result of the Rio+20 talks is the *Sustainable Development Goals* (SDGs). In September 2015 the UN agreed on the 2030 Sustainable Development Goals, the 15-year global framework that came into effect in January 2016. While specific goals for the transport sector are specifically considered in the SDGs, the sector is recognised as a facilitator of goals i.e. important means of achieving various goals. The inclusion of transport-related targets in seven out of the 17 SDGs (Goals 2, 3, 7, 9, 11, 12, and 13) illustrates the cross-cutting role that transport has in sustainable development (Table 4).

For developing countries to monitor progress towards these targets requires comprehensive data collection of transport activity and impacts. In fact, the SDGs recognise the lack of availability of data: ‘*We recognise that baseline data for several of the targets remain unavailable, and we call for increased support for strengthening data collection and capacity building in Member States, to develop national and global baselines where they do not yet exist. We commit to addressing this gap in data collection to better inform the measurement of progress, for those targets [...] which do not have clear numerical targets.*’ (UNDESA, 2015)

Table 4: Relevance of transport sector in sustainable development goals as reflected in the final list of proposed SDG indicators

Goals	Target	Indicators ¹
<i>Items Directly Related to Transportation</i>		
3. Ensure healthy lives and promote well-being for all at all ages (road safety)	3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	Death rate due to road traffic injuries
7. Ensure access to affordable, reliable, sustainable and modern energy for all (Energy efficiency)	7.3 By 2030, double the global rate of improvement in energy efficiency	Energy intensity measured in terms of primary energy and GDP
9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation (sustainable infrastructure)	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Proportion of the rural population who live within 2 km of an all-season road Passenger and freight volumes, by mode of transport

Goals	Target	Indicators ¹
11. Make cities and human settlements inclusive, safe, resilient and sustainable (sustainable transport for all, including urban transport)	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Proportion of urban population living in slums, informal settlements or inadequate housing Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
<i>Items indirectly related, but relevant to transport</i>		
3. Ensure healthy lives and promote well-being for all at all ages (air pollution)	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Mortality rate attributed to household and ambient air pollution
11. Make cities and human settlements inclusive, safe, resilient and sustainable (sustainable cities)	11.6 By 2030, reduce the adverse per-capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Annual mean levels of fine particulate matter in cities (population-weighted)

These recent developments show that the impetus to better integrate transportation into sustainability issues is increasing, and the need to establish understandable, robust, and appropriate sustainable transport indicators is becoming more evident.

2.4. Regional-level recognition of the importance of transport data and indicators

ASEAN has been continuing its progress towards establishing monitoring mechanisms that will support the region in achieving more sustainable transportation pathways. Several key guidance documents and regional-level statements have been issued by ASEAN that recognises such monitoring mechanisms as enabling factors towards sustainable transport, as discussed in this section.

Issued by the ASEAN

- The KLTSP serves as ASEAN's regional policy guidance document, and includes specific goals, actions, and milestones for the different transport modes (air, land, maritime), as well as for sustainable transport. The KLTSP was adopted in November 2015 and is intended to support the realisation of the ASEAN Economic Community 2025 which embodies a cohesive regional economy. The KLTSP is guided by the post-2015 vision that was adopted by the ASEAN Transport Ministers: 'Towards greater connectivity, efficiency, integration, safety and sustainability of ASEAN transport to strengthen ASEAN's competitiveness and foster regional inclusive growth and development' (ASEAN, 2016).

The sustainable transport pillar of the KLTSP includes a goal to identify and implement key measures on sustainable transport (ST-2). Under this goal is a specific action (ST-2.3) on the development of a monitoring framework and harmonised approach for indicators on energy and GHG emissions in the transport sector. The said action includes specific milestones such as the conduct of necessary consultations, and studies on potential indicators and monitoring mechanisms, as well as the adoption of an action plan to develop and operationalise the indicators and/or monitoring and indicators, and the compilation of data for the indicators.

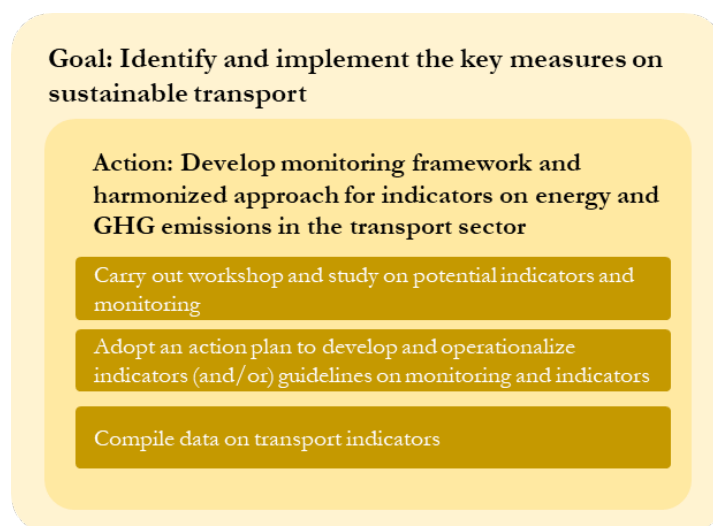


Figure 4: Relevant KLTSP goal, action, and milestones (Source: ASEAN, 2015)

- The bloc has also adopted the ASEAN Framework of Cooperation in Statistics (AFCS). The Framework has the overall objective of strengthening ASEAN's capacity to produce timely and comparable statistics, including the establishment of an ASEAN Community Statistical System. It recognises that there is a *'need to develop more relevant indicators, and to produce, disseminate and communicate more timely and comparable statistics supports evidence-based policy making, planning and monitoring for ASEAN.'* The ASEAN Statistical Indicators, which detail the broad statistical domains that the ASEAN Community Statistical System (ACSS) are committed to produce, include transportation-related indicators (ASEAN Secretariat, 2014).

Issued by ASEAN with other development partners

- The First ASEAN and Japan Transport Ministers' Meeting held in October 2003 in Yangon (ASEAN, 2003) adopted the terms of reference for ASEAN-Japan Transport Partnership (AJTP). One of the key deliverables of the AJTP was the ASEAN-Japan Transport Statistics Book. This initiative was endorsed in the second ASEAN and Japan Transport Ministers' Meeting, held in Cambodia. In order to develop this database, seminars and expert meetings have been organised annually. The AJTP Information Centre was opened to the public in 2011, under the Operational Guidelines of the ASEAN-Japan Transport Statistics Database, which was endorsed by the Seventh ASEAN and Japan Transport Ministers' Meeting, held in Viet Nam in

2009. Finally, in 2013, the Transport Policy Officials Training Programme (ASEAN, 2013) conducted capacity building for utilisation of transport databases in drafting transport policy planning.

- The sixth ASEAN-Japan Transport Ministers Meeting adopted the Manila Action Plan (ASEAN, 2009), which consists of a policy-oriented framework for cooperation with four pillars, namely: (a) safety and security; (b) transport logistics; (c) environment; and (d) common infrastructure, to further advance the regional economic integration taking into account emerging global and regional issues. It recommended that, to promote a low-carbon society, it is important to formulate and implement appropriate transport policies based on timely and reliable statistics.

Issued by non-ASEAN multi-national processes, but relevant to ASEAN Member States

- The Ministerial Conference on Global Environment and Energy in Transport (MEET, 2009) held in Tokyo in January 2009 called for: ‘the improvement of the accuracy, adequacy and comparability of statistics on environment and energy for transport to support effective policy making and assessment of progress as one of the elements necessary in order to achieve their shared long-term vision of realising low-carbon and low-pollution transport systems that also ensure sustainable development.’
- The workshop on Statistics of Asian Traffic and Transportation held in Tokyo on 10-11 March, 2008 to discuss current statistical data issues in Asia recommended that *‘to avoid unnecessary overlapping of data collecting efforts, we, under corporation with organisations concerned, should continue efforts for developing common and overall database available for researchers, professionals, industry, stakeholders, and authorities to meet their specific needs. The common database may possess network structures with linking national and sectorial database developed respectively’* (Ministry of Land, Infrastructure, Transport and Tourism, 2008).

3. Existing initiatives and best practices

The formulation of the Guidelines, and the selection of the indicators were guided by the lessons learned from existing regional initiatives on transportation indicators. The following section provides examples of similar existing regional/multi-country transport data initiatives, and best practices that may be useful for establishing a monitoring mechanism for sustainable transport indicators in the ASEAN.

3.1. EU Transport and Environment Reporting Mechanism indicators

One of the most successful regional initiatives on transport indicators is the Transport and Environment Reporting Mechanism (TERM) of the European Union. The establishment of the TERM was spearheaded by the European Commission and the European Environmental Agency (EEA). The main objective of development of TERM indicators was to help EU member countries to monitor progress with their transport integration strategies, and to identify changes in policies, strategies and investments. The need for indicators for the monitoring of policies and investments at regional level was mainly due to the EU's Fifth Environmental Action Programme (5EAP), and to the Commission's 1998 Communication on Integration and Treaty of Amsterdam. This led to setting up of TERM indicators in 1998. Along with the annual publication of TERM indicators, a statistical compendium is also published, containing the transport and environmental data that is required for indicator compilation as well as specific focus reports on topics that require a more detailed assessment.

The annual TERM report provides an overview of transport demand and pressures from the sector on the environment, as well as selected related impacts and policy responses. The EEA publishes the TERM indicator reports that focus on monitoring and reporting the progress towards integrating environmental objectives in transport since 2000. As with other environmental indicators that are reported at the EU level, the TERM indicators are based on the EEA's 'Typology of Environmental Indicators', a classification of indicators based on following questions (EEA, 1999):

'What is happening to the environment? Does it matter? Are we improving? Are we on the whole better off?'

The indicators are selected based on the DPSIR approach (driving forces, pressures, state, impact and responses), which connects the causes of environmental problems, their impacts and society's responses to them in an integrated way. Currently, TERM indicators are also used to monitor specific policy targets for transport established in the European Commission's White Paper on transport (EC, 2011). It is important to note that the initiative also experienced challenges related to data (e.g. availability, quality, timeliness) during the inception phase. In 1998, a review of the available data, and indicators was conducted, and it found that out of the 27 indicators:

- only one indicator was possibly complete, reliable and harmonised;
- 11 indicators were incomplete and lacking time series data;
- 14 indicators were unreliable and un-harmonised; and
- one indicator had serious problems, with no harmonised methodologies or data available.

(EEA, 1999)

The TERM initially covered data and indicators for 15 member countries of the EU (EEA, 1999), and currently includes indicators for 33 countries under the European Economic Area. If data is not available in certain Member States, this is noted in the report, but it is still being collected from countries which can provide the data.³

3.2. Environmentally Sustainable Transport - Bangkok 2020 indicators

The Bangkok 2020 Declaration is a significant milestone for the scaling-up of Environmentally Sustainable Transport (EST) in Asia as it is the first time Asian governments and other stakeholders in Asia endorsed a declaration which incorporates a comprehensive set of goals (20 EST Goals) (UNCRD, 2010) under different strategies concerning EST within a clear time frame (2010-2020). It is also the first regional policy declaration on EST in Asia that includes performance indicators for each strategic goal and encourages governments to voluntarily benchmark progress towards establishing sustainable transport systems.

Nearly 20 Goals with 105 indicators are proposed for monitoring progress towards the goals. In terms of strategies, the *avoid* strategy has three goals with 17 indicators, the *shift* strategy has four goals with 33 indicators, and the *improve* strategy has five goals with 16 indicators. Cross cutting strategies consist of eight goals with 39 indicators. The indicators proposed are:

- vehicle-kilometres (VKM) travelled per capita at metropolitan and national levels;
- mode share of all major transport modes at the metropolitan and national levels; and
- fuel efficiency levels of passenger and freight fleets.

However, the indicator reporting is sought only voluntarily (UNCRD, 2010) for monitoring the impact. The recent Bangkok 2020 Declaration (UNCRD, 2015) evaluation review noted that: *'Currently, quality of transport planning data is highly variable in Asia. Some jurisdictions have excellent data, but others lack basic data, such as motor vehicle ownership and type, roadway quality, and traffic casualties. Even where high quality data are available, they are often incompatible with data collected at other times and places, making it difficult to track and compare changes. This may be an opportunity to improve transport planning data by establishing Asia-wide standards for basic data collection practices, similar to current efforts to standardise European transport statistics. This effort could be coordinated by international or professional organisations.'* One of the main recommendations of the review

³ The European Economic Area includes the EU countries, as well as Iceland, Liechtenstein, and Norway.

was that: *'The EST Forum can provide a platform to develop global or regional standards and best practices for planning data collection.'*

3.3. ASEAN-Japan transport statistics database

The ASEAN-Japan Transport Information Platform Project was adopted as one of the activities under the ASEAN-Japan Transport Partnership (AJTP) during the second ASEAN-Japan Transport Policy Workshop held in August 2004 in Tokyo, Japan and then at the second ASEAN-Japan Transport Ministers Meeting in November 2004, in Phnom Penh, Cambodia. This project establishes the framework for common data collection and reporting for transport statistics. In this project, an AJTP Information Centre website was launched in 2005 featuring Common Data Templates for collection of transport statistics database. The AJTP Information Centre website functions as a tool for sharing transport statistical data in ASEAN and Japan, as well as information on progress of individual projects under the AJTP. In 2008 in the second ASEAN-Japan Transport Information Platform Experts Meeting discussed the Common Data Templates embedded in the AJTP Information Centre website, which contain data on basic statistical indicators in the transport sector, as well as some directions that may be considered in the future towards improving the database.

Further, in 2009, the operational guidelines for the AJTP transport statistics database were approved in December 2009 at the 7th ASEAN- Japan Transport Minister Meeting in Hanoi, Viet Nam. The guidelines provide an operational framework that consolidates the useful findings and learnings gained from the various initiatives under the ASEAN-Japan Transport Information Platform Project. In 2011, delegates at the ninth ASEAN-Japan Transport Ministers Meeting endorsed the sharing of the AJTP Statistics Database Website to the public. The website was opened to public on 26 December 2011.

The road transport database has a wide set of indicators including for road transport infrastructure, road transport measurement and traffic accidents, among others.⁴ However, indicators that focus on, or are highly relevant to energy consumption, efficiency and GHG emissions are not included in the database.

4 The complete list of indicators is categorised as follows: Road Infrastructure - 4 indicators; Road transport equipment - 7 indicators; Road transport measurement - 7 indicators; Other enterprises - 10 indicators; Road traffic accidents - 3 indicators; and Miscellaneous - 16 indicators

4. Introduction to the sustainable land transport indicators on energy efficiency and GHG emissions in ASEAN

There is a need for indicators that measure performance of policies and their impact on emissions and other externalities. An indicator is a variable, based on measurements, representing as accurately as possible and necessary a phenomenon of interest such as sustainable transport (Cost 356, 2005). This section explains the basis for, and the list of the selected indicators, as well as the structure of the indicator factsheets. The suggested indicators are meant to provide orientation and guidance and should not be understood as a binding set of indicators to monitor the transport sector. Many indicators are independent from each other, which allows for a flexible collection of the most suitable indicators that are adapted to national circumstances.

4.1. Key principles

Indicators are the most important tools available for monitoring and measuring progress towards a defined goal. Appropriate indicators are able to capture relevant and useful information that can guide decisions. Effective monitoring and accounting indicators (GIZ, 2016) should have following characteristics:

- Accessible - Required data are accessible by all stakeholders involved without restrictions.
- Comprehensive - Data are complete and available for all relevant indicators. A broad range of data should be collected to allow various types of analysis along multiple dimensions. There is a need to disclose and justify any specific exclusions.
- Consistency - Data from various sources is consistent and allows comparison between different sources and jurisdictions, and over time. It is important to document changes in definitions, boundary, methodology and frequency. Consistency in format is also critical to ensure quality and comparability.
- Cost-effective – the cost of acquiring indicators and data matches their relevance. They should be useful and provide added value to decision-making processes.
- Frequency - Regular data collection is a prerequisite for trend estimations.
- Relevance - Data matches the requirements from the monitoring system and the indicators.
- Transparent - Assumptions are explicitly explained and substantiated. The methods used to collect statistics must be accessible for review.

4.2. Framework for indicator selection

The indicators included in these Guidelines were identified by considering a bottom-up framework that identifies the primary components necessary for estimating the energy consumption and emissions from the transportation sector, based on Schipper, et al. (2000). This Activity-Structure-Intensity-Factor (ASIF) framework is a globally recognised framework for calculating emissions from the transportation sector that links travel activity, the structure of the transport system and its components, fuel efficiency factors, and emission factors, as seen in the equation below.

Activity and mode share (A, S) reflects the demand for passenger and freight transport, which are measured in terms of passenger-km or tonne-km (activity) and disaggregated by the transport modes (structure). Passenger-km or tonne-km are calculated using number of vehicles, number of trips, distances travelled and occupancy or loading of vehicles. Fuel intensity (I) of a mode is generally measured in energy units per passenger-km i.e. litres of fuel per passenger-km or megajoules (MJ) per passenger-km. Certain factors influence energy intensity, such as average occupancies, driving behaviour, vehicle engine technology, weight, aerodynamic design, and congestion on the road. (F) refers to the factor of emissions specific to the vehicle segments.⁵

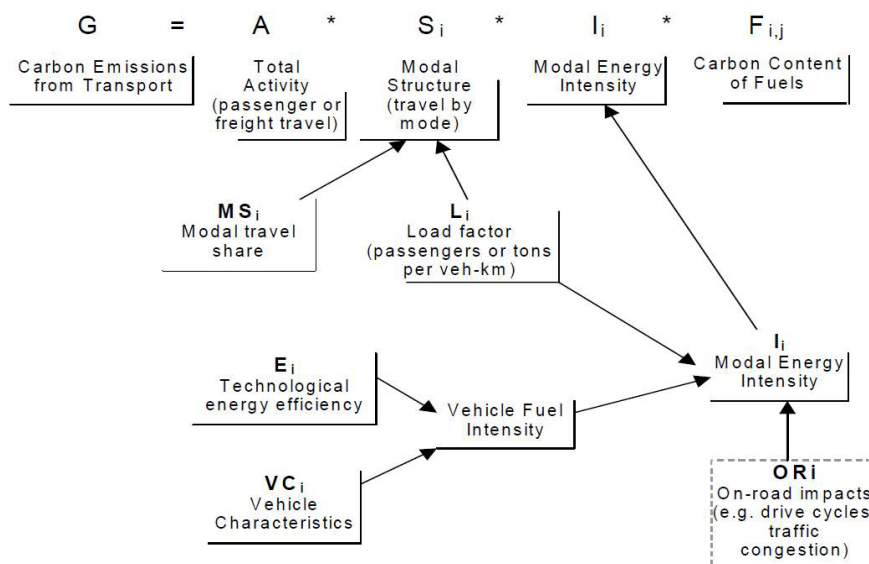


Figure 5: ASIF Framework
Source: Schipper, et al. (2000)

The use of such a bottom-up calculation framework enables better understanding of the factors that are influencing total transport energy consumption and emissions and provides additional insights that would not have been possible using a top-down approach which is based on aggregated fuel consumption (commonly based on fuel sales) estimates. Moreover, the availability of data for the aforementioned bottom-up parameters would improve the evaluation of different interventions towards achieving more efficient or less

⁵ These emission factors are ideally to be based on studies that incorporate local conditions, and vehicle characteristics.

polluting transport systems. Data and information needed for sufficiently addressing the basic needs for an ASIF-based calculation are available for most of the ASEAN Member States .

Bottom-up quantification and monitoring can potentially be complex, time-consuming, and costly, particularly if such processes are viewed in isolation. Prioritisation of key indicators and data parameters is recommended particularly for developing countries, but long-term goals should be based on continuous improvement. It is important to note that many of the data parameters required for GHG quantifications are also required for estimating air pollutant emissions, congestion, travel time and monitoring activity levels – parameters that are directly linked to different social, environmental, and economic goals.

4.3. List of indicators

Table 5 below shows the list of the indicators that are included in these Guidelines. These have been selected based on the framework discussed in section 3.2., and the process was guided by the emerging drivers, key principles, as well as the lessons learned, and success factors from the other existing regional initiatives. The indicators are presented as components relating to the ASIF framework, and as indicators they describe the measurement of transportation activity, equipment, infrastructure, energy, emissions, economy, and safety. These are categories that have been adopted by similar indicator documents, such as the International Transport Forum's (ITF) Glossary for Transport Statistics, and the AJTP statistics database. The table below lists the indicators grouped according to relevant categories (general, and ASIF), as well as descriptions of the nature of these indicators in relation to each other. The descriptions of whether the indicators are to be calculated or collected from existing sources are indicative, depending on the available information.

Table 5: Sustainable land transport indicators for energy efficiency and GHG emissions for ASEAN

The table below provides information about the indicators that have been selected as part of these Guidelines. The ‘description’ column provides brief descriptors which explain the nature of the indicators, either treated as direct inputs or derived values based on the simple equations provided. The bracketed numbers depict the indicator number of the variable in this table. There is more detailed information about the indicators in the fact sheets in Chapter 4.

General Category	ASIF Parameters	No.	Indicators	Description ²
Transport Measurement	Activity and Structure	1	Total population	Directly inputted values
		2	Motorisation rates	(9) Total road vehicles/ (1) Total population
		3	Total VKM travelled	Directly inputted values or Sum of: (9) Total road vehicles (by vehicle type) * average VKM (by vehicle type)
		4	VKM per capita	(3) Total passenger VKM/ (1) Total population
		5	Total passenger-kilometres (PKM) by transport mode	Directly inputted values or Sum of (9) Total road vehicles (by vehicle type) * average occupancies of passenger vehicles (by vehicle type)
		6	PKM per GDP by transport mode	(5) Total PKM by transport mode / gross domestic product
		7	Total tonne-kilometres by transport mode	Directly inputted values or Sum of (3) Total freight VKM travelled (by vehicle type) * (11) average loads of freight vehicles (by vehicle type)
Equipment	Activity and Structure	8	Tonne-kilometres per GDP by transport mode	(7) Total tonne-kilometres by transport mode / (27) gross domestic product
		9	Total road vehicles	directly inputted values
		10	Average occupancies of road passenger vehicles	directly inputted values
		11	Average loads of road freight vehicles	directly inputted values
		12	Alternative-fuel vehicle proportion of the road vehicle fleet	directly inputted values
Infrastructure	Activity and Structure	13	Share of renewable energy in total energy consumption by transport mode	directly inputted values
		14	Kilometres of road and rail infrastructure	directly inputted values

General Category	ASIF Parameters	No.	Indicators	Description ²
Energy	Intensity Factors	15	Average road vehicle fuel economy	directly inputted values
		16	Average road vehicle speeds	directly inputted values
		17	Total energy consumption by transport mode	Top down approach: directly inputted values or Bottom-up approach: Sum of (9) Total road vehicles (by vehicle type) * (3) total VKM (by vehicle type) * (15) average vehicle fuel economy (by vehicle type)
	Consumption	18	Energy consumption per GDP by transport mode	(17) Total energy consumption by transport mode / (27) GDP
	Factor of Emissions	19	Particulate matter emission factors of road vehicles	directly inputted values
Emissions	Emissions	20	NO _x emission factors of road vehicles	directly inputted values
		21	Total GHG emissions by transport mode	(17) Total energy consumption by transport mode * GHG emission factors * global warming potential of the GHGs
		22	Transport GHG emissions per capita by transport mode	(21) Total transport GHG emissions by transport mode / (1) total population
		23	Passenger transport GHG per PKM by transport mode	(21) Total passenger transport GHG by transport mode / (5) Total PKM by transport mode
		24	Freight transport GHG per TKM	(21) Total freight transport GHG by transport mode / (7) total tonne-kilometres by transport mode
		25	Road transport particulate matter emissions	Sum of (9) Total road vehicles * (3) total VKM * (19) particulate matter emission factors
		26	Road transport NO _x emissions	Sum of (9) Total road vehicles * (3) total VKM * (20) NO _x emission factors
Economic		27	Gross domestic product	directly inputted values
		28	Freight rates	directly inputted values
		29	Fossil fuel subsidy for transport	directly inputted values
		30	Transport infrastructure investments	directly inputted values
		31	Climate finance for transport	directly inputted values
Safety		32	Road fatalities per million vehicles	directly inputted values / (9) total road vehicles – expressed in millions
		33	Road non-fatal injuries per 10,000 Vehicles	directly inputted values / (9) total road vehicles – expressed in 10 thousands

4.4. Structure of the indicator factsheets

Factsheets for each of the indicators have been developed in order to provide succinct but valuable guidance on data collection, calculations, and interpretation of resulting values for the indicators. The factsheets are structured to be concise. Table 6 below shows the description of each of the sections of the factsheets.

Table 6: Factsheet template

Section	Description
Description	<p>This section provides the widely used definitions and descriptions of the indicator.</p> <p>Examples are also given to provide information about the existing ranges of values. As much as possible, ASEAN-specific indicators are used, otherwise, existing values for other countries are included.</p>
Objective and relevance	This section discusses the importance of the indicator, and what it aims to provide information on.
Unit of measurement	This provides information on common units of measurement for the indicator.
Methodology	This section provides the common methods for collecting the data needed for the derivation of the indicator, as well as the associated equations as applicable; appropriate best practices will also be included, such as data generation and validation, if available. Default values will be included, if available.
Potential data sources	This section discusses the common institutional sources of data needed for the derivation of the indicator values, or other highly relevant sources of relevant information.
Remarks	This section discusses issues relating to the derivation of the data for the indicator, as well as issues that need to be considered in interpreting the indicator.
Related indicators	The 'related indicators' refer to those indicators within the whole set of indicators included in these Guidelines which are either inputs to, or dependent indicators of the specific indicator that is discussed.

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1. Total population

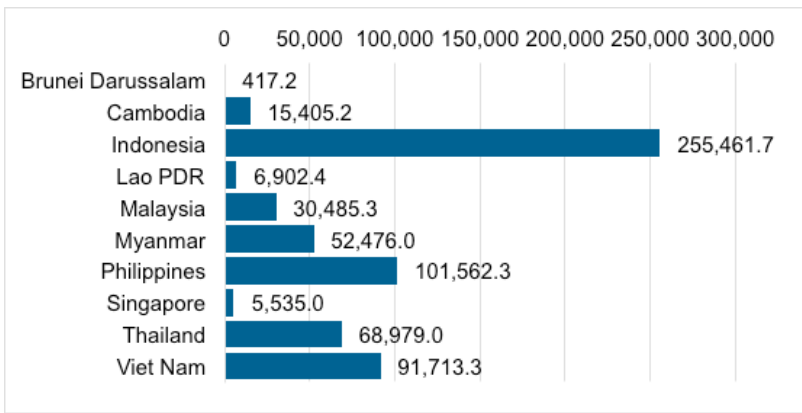
Section	Description																						
Description	<p>This indicator provides the size of the country's population for a given year. Total population numbers are primarily based on census data.³ ASEANStat defines total population as typically comprising of permanent inhabitants, and/or persons present within the territorial boundaries of the country at a certain point in time.⁴</p> <p><i>Illustrative example</i></p>  <table border="1"> <thead> <tr> <th>Country</th> <th>Population ('000s)</th> </tr> </thead> <tbody> <tr> <td>Brunei Darussalam</td> <td>417.2</td> </tr> <tr> <td>Cambodia</td> <td>15,405.2</td> </tr> <tr> <td>Indonesia</td> <td>255,461.7</td> </tr> <tr> <td>Lao PDR</td> <td>6,902.4</td> </tr> <tr> <td>Malaysia</td> <td>30,485.3</td> </tr> <tr> <td>Myanmar</td> <td>52,476.0</td> </tr> <tr> <td>Philippines</td> <td>101,562.3</td> </tr> <tr> <td>Singapore</td> <td>5,535.0</td> </tr> <tr> <td>Thailand</td> <td>68,979.0</td> </tr> <tr> <td>Viet Nam</td> <td>91,713.3</td> </tr> </tbody> </table>	Country	Population ('000s)	Brunei Darussalam	417.2	Cambodia	15,405.2	Indonesia	255,461.7	Lao PDR	6,902.4	Malaysia	30,485.3	Myanmar	52,476.0	Philippines	101,562.3	Singapore	5,535.0	Thailand	68,979.0	Viet Nam	91,713.3
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Objective and relevance	<p>Population-related data and associated indicators are used for a variety of purposes. For these Guidelines, total population is used to derive per-capita values for several indicators (e.g. VKM/capita, passenger-kilometres/capita, among others) which are useful in indicating intensities, and the movement of such intensities.</p>																						
Unit of measurement	<p>Total population is provided in terms of <u>persons/year</u>.</p>																						
Methodology	<p>Datasets are normally readily available from official sources based on population censuses.</p>																						
Potential data sources	<p>Population data is readily available from the ministries handling national statistics, or those which are directly looking at issues related to population and/or immigration issues.</p> <p>Other international databases also collate and provide total population estimates at the country level.</p>																						

Figure 6: Population ('000s) in the ASEAN Member States (Source: ASEANStat)

Remarks	The provision of population estimates for geographical sub-levels (e.g. urban, rural), which is useful to evaluate trends in the efficiency of transportation and in the strategic directions in terms of policy interventions, particularly as the ASEAN Member States are all moving towards higher urbanisation levels.
Related indicators	4. VKM per capita 18. Energy consumption per GDP by transport mode 22. Transport GHG emissions per capita by transport mode

2. Motorisation rates

Section	Description
Description	<p>This indicator is a measure of the levels of motorisation in terms of the number of vehicles per thousand people.</p> <p><i>Illustrative example</i></p> <p>Figure 7: Motorisation rates estimates – Vehicles/1000 persons (Source: ITPS and CAA, 2012)</p>
Objective and relevance	Motorisation indices can indicate vehicle dependence. Comparison with other countries can provide insights for policymakers.
Unit of measurement	Motorisation indices are provided in terms of total vehicles/1,000 people.
Methodology	Vehicle population statistics, normally based on registration numbers, are divided by population numbers expressed per 1,000 people to calculate this indicator. It is important to note which vehicle categories/types are included in calculating the indices (e.g. passenger, freight, etc...). Calculating motorisation indices for each vehicle type can also be done using the vehicle registration data.

$$MI = \sum \left(\frac{Vehicle\ Pop_i}{Pop/10^3} \right)$$

Where:

MI = motorisation index for vehicle type i (vehicle/ thousand people)

Vehicle Pop_i = number of type i vehicles

Pop = total population

Potential data sources	Vehicle registration data are normally with the ministries of transport, while population data is available from the national statistics ministries.
Remarks	<p>While motorisation indices are useful in providing bases for comparing levels of ownership, they do not necessarily indicate levels or intensity of vehicle use. Other iterations of the indicator can be calculated, such as:</p> <ul style="list-style-type: none">- total vehicles/1000 people per vehicle type;- total passenger vehicles/1000 people; and- total freight vehicles/1000 people.
Related indicators	<ol style="list-style-type: none">1. Total population9. Total road vehicles

3. Total road vehicle-kilometres travelled

Section	Description
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Description This indicator is a measure of the total distance travelled by road vehicles in a given year. It is often used as a primary activity data for bottom-up estimation of energy consumption and of emissions from road transportation.

Illustrative example

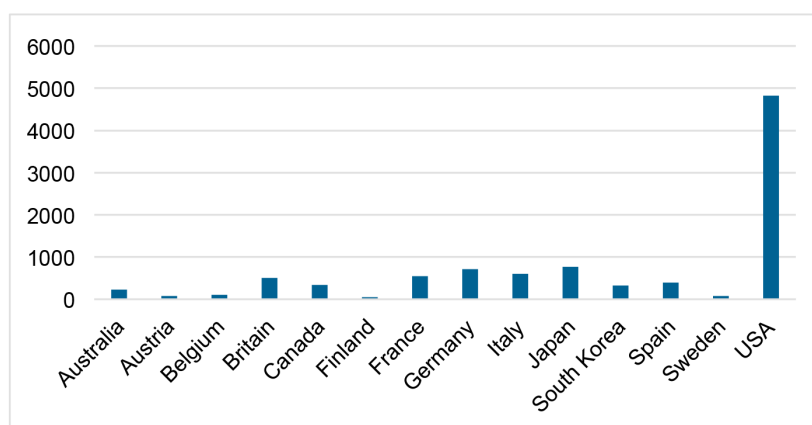


Figure 8: Total VKM (billions) estimates for selected countries (Source: BITRE, 2012)

Objective and relevance The provision of VKM data disaggregated by vehicle type and by fuel type can provide essential insights on vehicle activity in a given country. VKM data is also commonly used for estimating emissions.

Unit of measurement This indicator is reported in terms of vehicle-kilometres (VKM), sometimes, it is also referred to as vehicle-kilometres travelled (VKT). In other countries that use the imperial system of measurement, this is referred to as VMT or vehicle-miles travelled.

It is recommended that VKM/year be used as the unit of measurement, as this is commonly used in the ASEAN Member States.

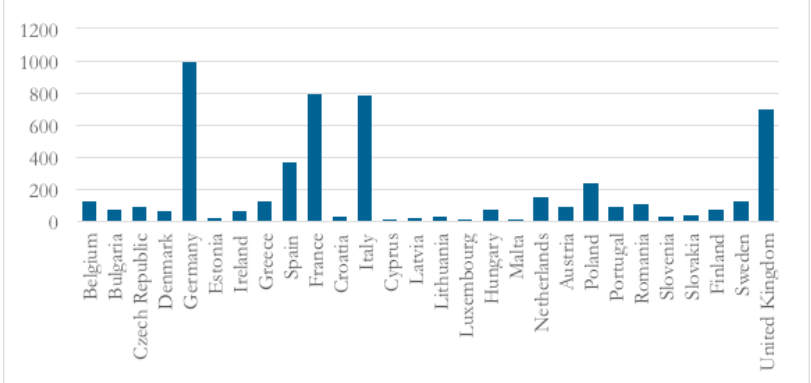
Methodology	<p>Ideally, comprehensive VKM estimates can be derived from aggregated odometer readings for the registered vehicle population, if these are conducted during the regular vehicle inspection procedures, or during the recurring vehicle registration processes. If so, generating this data for different segments (e.g. by vehicle type, or by fuel type, or combination of these) is feasible. However, in many countries including in ASEAN, this is not practiced. However, existing studies may have taken sample surveys that can be used in estimating total vehicle kilometres for different segments of the vehicle fleet. Average VKT/year/vehicle type (or by vehicle-fuel type) can then be multiplied by the respective population numbers for the vehicle segment, to estimate total VKM for that vehicle fleet segment. It must be noted that such averages are normally generated using sampling designs that are constrained within a certain area (e.g. for an urban transport study for a certain region, or for feasibility studies for certain transport projects), and that these averages may not necessarily be reflective of the real average for the population of vehicles, as vehicular activity may greatly vary from one area to another. The simplified method of estimating total VKT is given below:</p>
	<p>Where: $VKM_i = VehiclePop_i * AVKM_i$</p> <p>VKM_i = total vehicle kilometres travelled by road vehicles/year</p> <p>VehiclePop_i = number of vehicle type <i>i</i></p> <p>AVKM_i = average vehicle kilometres travelled by vehicle type <i>i</i> (VKM/year)</p> <p><i>i</i> = vehicle type</p>
Potential data sources	<p>As mentioned above, data based on aggregated odometer readings from vehicle registries are ideal, if available. In the absence of comprehensive data, average values from relevant studies are most often used.</p>
Remarks	<p>Default values or ranges for average VKM can provide useful starting points for estimating total VKM per vehicle segment. These can also be adjusted accordingly by analysing, for example, the energy estimates generated using these values, combined with known vehicle numbers and estimated average fuel efficiencies. Other indicators can also be calculated using the specified data, including:</p> <ul style="list-style-type: none"> - total VKM/vehicle type; - total passenger VKM; and - total freight VKM.
Related indicators	<ol style="list-style-type: none"> 4. VKM per capita 5. Total PKM by transport mode 7. Total tonne-kilometres by transport mode 8. Tonne-kilometres per GDP by transport mode 25. Road transport particulate matter emissions 26. Road transport NOx emissions

4. Road vehicle-kilometres per capita

Section	Description
<p>Description</p>	<p>This indicator is a measure of the level of motorised travel activity performed by an individual. It is a generalised estimate, as it is based on aggregated vehicle activity estimates and population estimates.</p>
<p><i>Illustrative example</i></p>	<p>The graph displays the trend of road vehicle-kilometres per capita for 20 countries from 1963 to 2010. The y-axis represents '000 vehicle kilometres per person per year' (0 to 18), and the x-axis shows years from 1963 to 2010. The USA (dark blue line) shows the most dramatic increase, starting at approximately 6,000 VKM/capita in 1963 and reaching about 15,000 by 2010. Australia (black line) and Germany (green line) also show strong growth. Turkey (red line) remains the lowest, starting near 0 and ending around 1,000 VKM/capita.</p>
<p><i>Figure 9: 2015 Vehicle-kilometre/ capita estimates for various countries (Source: BITRE, 2012)</i></p>	
<p>Objective and relevance</p>	<p>Vehicle-kilometres travelled per capita (VKM/capita) is essential in generating insights about the general efficiency of a passenger transport system. The levels of VKM/capita travelled in low-occupancy, personal vehicles are of particular importance, particularly for daily commuting trips. This provides useful insights into how much motorised travel is required for people to conduct their activities and is an indicative measure of automobile dependence.</p>
<p>Unit of measurement</p>	<p>This indicator is reported in vehicle-kilometres/person/year (<u>VKM/capita/year</u>).</p>

Methodology	The indicator is calculated by dividing the total VKM of passenger vehicles by the total population within the scope of analysis.
	$VKMCAP_i = \frac{\sum VKM_i}{Pop}$
	<p>Where:</p> <p>$VKMCAP_i$ = average road VKM travelled per capita per year for vehicle type i</p> <p>VKM_i = total road vehicle kilometres travelled by vehicle type i</p> <p>Pop = total population</p> <p>i = vehicle type</p>
Potential data sources	As mentioned above, summarised data on odometer readings from the vehicle registry are ideal sources of data, if these are available. In the absence of such robust data, average values from relevant studies are most often used.
Remarks	At the country level, it is normal practice to take the aggregate VKM estimates and divide them by the population of the country to estimate VKM/capita. In other cases, VKM estimates are multiplied by the vehicle population estimates and the resulting figures are divided by the population estimates. Generating reasonable VKM estimates by vehicle type tends to be the most critical and challenging part, particularly if the data are only available for specific areas. Alternative estimation techniques can involve the extrapolation of sample estimates (e.g. from urban transport surveys) to the wider population.
Related indicators	<ol style="list-style-type: none"> 1. Total population 3. Total VKM travelled

5. Total passenger-kilometres by transport mode

Section	Description																																																										
Description	<p>A passenger-kilometre (PKM) is a measure of transport activity and represents the movement of one passenger over a kilometre (Eurostat, et al., 2009).</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="555 600 1369 981"> <caption>Data for Figure 10: Total road transport PKM (billions) for sample EU countries</caption> <thead> <tr> <th>Country</th> <th>Total road transport PKM (billions)</th> </tr> </thead> <tbody> <tr><td>Belgium</td><td>100</td></tr> <tr><td>Bulgaria</td><td>50</td></tr> <tr><td>Czech Republic</td><td>50</td></tr> <tr><td>Denmark</td><td>50</td></tr> <tr><td>Germany</td><td>1000</td></tr> <tr><td>Estonia</td><td>10</td></tr> <tr><td>Ireland</td><td>50</td></tr> <tr><td>Greece</td><td>100</td></tr> <tr><td>Spain</td><td>400</td></tr> <tr><td>France</td><td>800</td></tr> <tr><td>Croatia</td><td>50</td></tr> <tr><td>Italy</td><td>800</td></tr> <tr><td>Cyprus</td><td>10</td></tr> <tr><td>Latvia</td><td>10</td></tr> <tr><td>Lithuania</td><td>10</td></tr> <tr><td>Luxembourg</td><td>10</td></tr> <tr><td>Hungary</td><td>50</td></tr> <tr><td>Malta</td><td>10</td></tr> <tr><td>Netherlands</td><td>150</td></tr> <tr><td>Austria</td><td>100</td></tr> <tr><td>Poland</td><td>250</td></tr> <tr><td>Portugal</td><td>100</td></tr> <tr><td>Romania</td><td>100</td></tr> <tr><td>Slovenia</td><td>50</td></tr> <tr><td>Slovakia</td><td>50</td></tr> <tr><td>Finland</td><td>50</td></tr> <tr><td>Sweden</td><td>150</td></tr> <tr><td>United Kingdom</td><td>700</td></tr> </tbody> </table>	Country	Total road transport PKM (billions)	Belgium	100	Bulgaria	50	Czech Republic	50	Denmark	50	Germany	1000	Estonia	10	Ireland	50	Greece	100	Spain	400	France	800	Croatia	50	Italy	800	Cyprus	10	Latvia	10	Lithuania	10	Luxembourg	10	Hungary	50	Malta	10	Netherlands	150	Austria	100	Poland	250	Portugal	100	Romania	100	Slovenia	50	Slovakia	50	Finland	50	Sweden	150	United Kingdom	700
Country	Total road transport PKM (billions)																																																										
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Objective and relevance	<p>Monitoring this indicator is useful in evaluating the overall growth of passenger transport activity. It is most useful if the PKM data can be disaggregated into trip purpose (e.g. work, education, business, or leisure), by mode and vehicle types (e.g. car, bus, or motorcycle), geographic level (e.g. urban, rural, inter-urban, or inter-rural), among other categories, as these are essential in determining policy choices and future interventions.</p>																																																										
Unit of measurement	<p>This is measured in terms of passenger-kilometres (PKM), also referred to as passenger-kilometres travelled (PKT). In other countries that use the imperial system of measurement, this is referred to as passenger-miles travelled (PMT).</p> <p>It is recommended that PKM/year be used as the unit of measurement, as kilometres is commonly used as a measure of distance in the ASEAN Member States.</p> <p>These Guidelines propose that PKM figures be provided or calculated separately for road, and rail. Calculating PKM figures for each of the vehicle types would also be useful to monitor.</p>																																																										

Methodology

In developed countries (e.g. EU Member States), aggregated PKM estimates are generated using data from sample surveys (e.g. national transport surveys) that are primarily based on trip diaries.⁵ Such surveys intend to capture the trips done by members of a household, and generate data in terms of the following: number of trips; purpose of trips; modes used (including main mode); and time of travel, among others. Estimates of PKM for the whole population are then generated using the sample data.

In many of the developing countries, including those in ASEAN, passenger transport surveys are conducted as a part of either project feasibility studies or academic studies, but not normally as a regular data collection activity with the intent of monitoring transport-related parameters. A simplified approach for estimating PKM values for a given mode is given in the equation below:

$$PKM_z = \sum (AVKM_x * VehiclePop_x * AO_x)$$

Where:

PKM_z = total passenger kilometres performed by passenger vehicles (PKM) under mode z

$VehiclePop_i$ = number of passenger vehicle type i

$AVKM_x$ = average vehicle kilometres travelled by passenger

AO_x = average occupancy of passenger vehicle i (PKM/VKM)

x = passenger transport vehicles under mode z

z = transport modes (e.g. road, rail)

* = multiplication

The population estimates (e.g. from vehicle registry) for vehicle type i are multiplied by the estimated average VKM driven which results in total VKM/year, and this is multiplied with observed sample estimates of average occupancies.

For modes that have detailed data on passenger embarkation and disembarkation as well as origins and destinations, such as rail, PKM can be calculated based on the number of passengers on a particular flow multiplied by the track kilometres between the two stations in the said flow (ORR, 2016).

Potential data sources

Site-specific estimates may be available from project feasibility reports, particularly for major urban areas, or from government surveys, and can be useful in gauging overall levels. As mentioned earlier, regular national transport surveys are ideal if resources allow. The advent of modern technology is also enabling more robust estimations of PKM (e.g. using GPS, mobile network, or wi-fi access data). Rail PKM data can be extracted based on the ticket sales, tap-on tap-off data, or similar datasets.

Remarks	Changes in the total estimates can be driven either by the total number of passengers taking trips within a certain transport system or by the changes in spatial configurations (e.g. suburban sprawl), which might not be evident if using the simple method based on VKM and average occupancies. Moreover, it is important to have disaggregated PKM values for the different modes, as these gives more relevant insights to the structure of the passenger transport system.
Related indicators	<ul style="list-style-type: none"> 3. Total VKM travelled 6. PKM per GDP by transport mode 9. Total road vehicles 10. Average occupancies of road passenger vehicles 23. Passenger transport GHG per PKM by transport mode

6. Passenger-kilometres per GDP by transport mode

Section	Description
Description	This indicator is a measure of passenger intensity, and is a ratio between the PKM and GDP. ⁶

Illustrative example

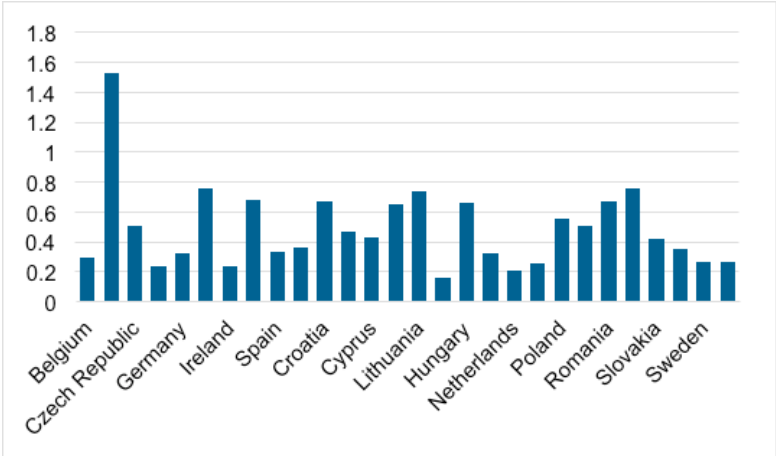


Figure 11: Road PKM/GDP⁷ for sample EU countries (Source: Eurostat website)

Objective and relevance	This indicator is important as it depicts the levels of passenger activity and how that relates to the economy. It can potentially provide insights into how much passenger transport is needed to deliver the current economic performance.
Unit of measurement	This indicator is reported in terms of <u>PKM/unit of GDP</u> . These Guidelines propose that PKM/GDP figures be provided or calculated separately for road and rail.
Methodology	Total PKM is divided by the GDP figures to obtain this indicator. Details on how to estimate PKM are found in Factsheet 5, while information about GDP is found in Factsheet 27.

$$PKMGDP_z = \frac{\sum PKM_x}{GDP}$$

- Where:
- PKMGDP_z = total PKM performed by mode z per unit of GDP
 - PKM_x = total PKM performed by vehicle type i
 - GDP = gross domestic product (preferably in current USD)
 - x = passenger vehicles belonging to mode z
 - z = transport modes (e.g. road, rail)

Potential data sources	The sources for the PKM data are discussed in Factsheet 5, while the data sources for GDP are discussed in Factsheet 27.
Remarks	Other related indicators such as PKM/capita by vehicle type might also be worthwhile exploring.
Related indicators	3. Total VKM travelled 5. Total PKM by transport mode 9. Total road vehicles 10. Average occupancy of road passenger vehicles 27. Gross domestic product

7. Total tonne-kilometres by transport mode

Section	Description
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Description This indicator is a unit of measurement indicating the transport of one tonne of goods over a kilometre (Eurostat, et al., 2009).

Illustrative example

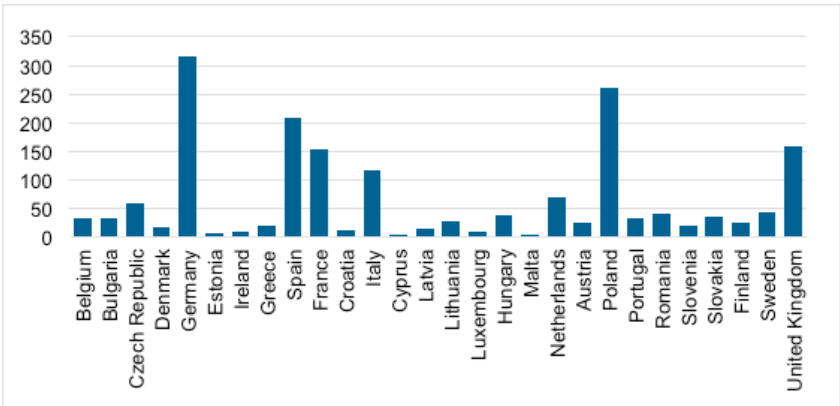


Figure 12: Total road tonne-kilometres (billions) for sample EU countries (Source: Eurostat website)

Objective and relevance This indicator depicts the level of freight activity as it combines distance with the amount of goods that are transported. Monitoring such an indicator can provide insights about the pace at which freight activity is growing. Comparing mode-specific values also provide insights about the relative importance of each mode in terms of performing freight activity, and can feed into policy making and intervention decisions.

Unit of measurement This is measured in terms of tonne–kilometres (TKM) performed by the different transport modes.

These Guidelines propose that TKM figures be provided or calculated separately for road and rail.

Methodology There are several ways by which data is generated for calculating the tonne-kilometre indicator. As the name implies, the indicator represents the transport of a tonne of cargo over a kilometre. In instances where comprehensive data is not available, vehicle-kilometre averages are multiplied by available estimates for average loads, to gauge the level of magnitude. While this is normally used as a starting point, ideally data from appropriately designed sample surveys should be generated. Alternatively, one can use data from commodity flow surveys, which collect data on the types and quantities of goods moved to and from establishments. This assumes that basic information on the modes used are collected, allowing the use of the aggregated tonnage data, together with the aggregated VKM data for goods vehicles (average VKM driven per goods vehicle * number of goods vehicles). The equation below describes the indicator.

$$TKM_z = \sum (AVKM_y * VehiclePop_y * AL_y)$$

Where:

- TKM_z = total tonne-kilometres performed by mode z
 AVKM_y = average vehicle kilometres travelled by freight vehicle type z (VKM)
 VehiclePop_y = number of freight vehicles type i
 AL_y = average load of freight vehicle i (TKM/VKM)
 y = freight vehicles belonging to mode z
 z = transport modes (e.g. road, rail)
 * = multiplication

Eurostat (2011), for example, produces guidelines on the conduct of road freight surveys, with the aim of generating data about the work done (transportation of goods), including data on the journeys, vehicles, and enterprises. The guidelines are based on agreements at the regional level (EU), and enterprises are randomly selected for participation, depending on the type of sampling design deemed appropriate by the country, based on budget, and with the aim of minimising errors.⁸

The surveys include the collection of enterprise data (e.g. type of company, operations, or fleet size), vehicle data, and journey-related data. The vehicle data includes parameters such as: age of the vehicle; type and amount of fuel purchased during survey period; body type of the vehicle and the trailer or semi-trailer; and total kilometres covered during the survey period. The provision of detailed vehicle data is also encouraged, e.g. make and model. The data collected for the journeys include details about the stages of the journey as well, as freight trucks can have multiple stops when delivering goods. Details about the spatial movements are also collected. This consists of first place of loading, last place of unloading, any countries crossed in transit, and interim places of loading and unloading. Data on the goods carried are collected, namely their type based on a standard classification, total weight of goods, cargo type⁹ and the distance travelled (Eurostat, 2011).

For modes such as rail that have detailed data on tonnage loaded, origins and destinations, tonne-kilometres can be calculated based on the net tonnage delivered on a particular flow, multiplied by the track kilometres between the two stations in the said flow (ORR, 2017).

Potential data sources

The simplest calculations can be done using average distances estimated for the type of vehicle involved (e.g. trucks), multiplying these by the vehicle population (therefore estimating total VKM), and by total tonnes moved (assuming that road transport tonnes estimates are available).

Alternatively, roadside surveys data can be used, estimating average loads (tonnes) and kilometres driven, and these can be multiplied with the population of the vehicles (categorised accordingly with the sample data). Rail data can be based on records for the cargo delivered through the network.

Remarks	Generating similar indicators for other modes (e.g. water-based or air-based freight activity) is also ideal in the long run, in order to have a more holistic image of how freight activity and growth are distributed among the different modes.
Related indicators	3. Total road VKM travelled 8. Tonne-kilometres per GDP by transport mode 9. Total road vehicles 11. Average loads of road freight vehicles 24. Freight transport GHG per TKM by transport mode

8. Tonne-kilometres per GDP by transport mode

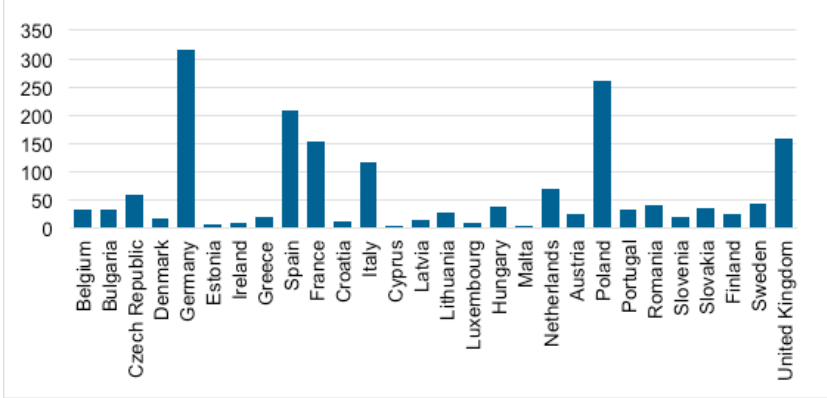
Section	Description																																																										
Description	<p>This indicator is a measure of freight intensity, which can be defined as the freight moved divided by the level of gross domestic product of an economy (Gleave, 2003).</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="571 607 1401 1003"> <caption>Data for Figure 13: Road tonne-kilometres/GDP (Euro) for sample EU countries</caption> <thead> <tr> <th>Country</th> <th>Value (Euro)</th> </tr> </thead> <tbody> <tr><td>Belgium</td><td>30</td></tr> <tr><td>Bulgaria</td><td>30</td></tr> <tr><td>Czech Republic</td><td>60</td></tr> <tr><td>Denmark</td><td>20</td></tr> <tr><td>Germany</td><td>320</td></tr> <tr><td>Estonia</td><td>10</td></tr> <tr><td>Ireland</td><td>10</td></tr> <tr><td>Greece</td><td>20</td></tr> <tr><td>Spain</td><td>210</td></tr> <tr><td>France</td><td>150</td></tr> <tr><td>Croatia</td><td>10</td></tr> <tr><td>Italy</td><td>110</td></tr> <tr><td>Cyprus</td><td>10</td></tr> <tr><td>Latvia</td><td>20</td></tr> <tr><td>Lithuania</td><td>20</td></tr> <tr><td>Luxembourg</td><td>10</td></tr> <tr><td>Hungary</td><td>40</td></tr> <tr><td>Malta</td><td>10</td></tr> <tr><td>Netherlands</td><td>70</td></tr> <tr><td>Austria</td><td>20</td></tr> <tr><td>Poland</td><td>260</td></tr> <tr><td>Portugal</td><td>30</td></tr> <tr><td>Romania</td><td>40</td></tr> <tr><td>Slovenia</td><td>20</td></tr> <tr><td>Slovakia</td><td>30</td></tr> <tr><td>Finland</td><td>20</td></tr> <tr><td>Sweden</td><td>40</td></tr> <tr><td>United Kingdom</td><td>160</td></tr> </tbody> </table>	Country	Value (Euro)	Belgium	30	Bulgaria	30	Czech Republic	60	Denmark	20	Germany	320	Estonia	10	Ireland	10	Greece	20	Spain	210	France	150	Croatia	10	Italy	110	Cyprus	10	Latvia	20	Lithuania	20	Luxembourg	10	Hungary	40	Malta	10	Netherlands	70	Austria	20	Poland	260	Portugal	30	Romania	40	Slovenia	20	Slovakia	30	Finland	20	Sweden	40	United Kingdom	160
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Sweden	40																																																										
United Kingdom	160																																																										
Objective and relevance	<p>This indicator is important in depicting the level of freight activity that is needed to achieve a unit of GDP. Ideally, the freight intensity per GDP for other modes should also be known to provide a complete picture.</p>																																																										
Unit of measurement	<p>This indicator is reported in terms of <u>tonne-km/unit of GDP</u>.</p> <p>These Guidelines propose that TKM/GDP figures be provided or calculated separately for road and rail.</p>																																																										

Figure 13: Road tonne-kilometres/GDP (Euro) for sample EU countries (Source: Eurostat)

Methodology Tonne-km data for freight is divided by the GDP figure in order to determine this indicator. Details on how to estimate tonne-km for road is found in Factsheet 7, while information about GDP is found in Factsheet 27.

$$TKMGDP_z = \frac{\sum TKM_y}{GDP}$$

Where:

$TKMGDP_z$ = tonne-kilometres performed per unit of GDP produced expressed in TKM/GDP

TKM_y = total tonne-kilometres performed by freight vehicles belonging to mode z

GDP = gross domestic product (preferably in current USD)

z = transport modes

This indicator can be viewed as a product of four factors: modal share, average haul, the number of times a product is handled to final consumption in the supply chain, and the average value density of the final products or total tonnes generated per unit of GDP (Gleave, 2003).

Potential data sources The sources for the tonne-kilometre data are discussed in Factsheet 7, while the data sources for GDP are discussed in Factsheet 27. Freight intensity indicators (e.g. in terms of tonne-km/GDP) are not currently being reported in the ASEAN Member States, which may be partly due to the difficulties in generating reliable tonne-kilometre estimates per mode.

Remarks Analyses of freight intensity indicators must also be assessed within the wider context. Ideally, intensity indicators should also be calculated for the other modes, namely rail, water and air. For example, low road freight intensities may not necessarily mean that freight intensity is low in general, it just might mean that the other modes are playing more substantial roles.

Related indicators

- 3. Total road VKM travelled
- 7. Total tonne-kilometres by transport mode
- 9. Total road vehicles
- 11. Average loads of road freight vehicles
- 27. Gross domestic product

17.

9. Total road vehicles

Section	Description
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Description Vehicle registration numbers are commonly used as an indication of the on-road vehicle stock population, which can then be used as a base parameter for estimating transport activity for bottom-up energy and emissions calculations.

Illustrative example

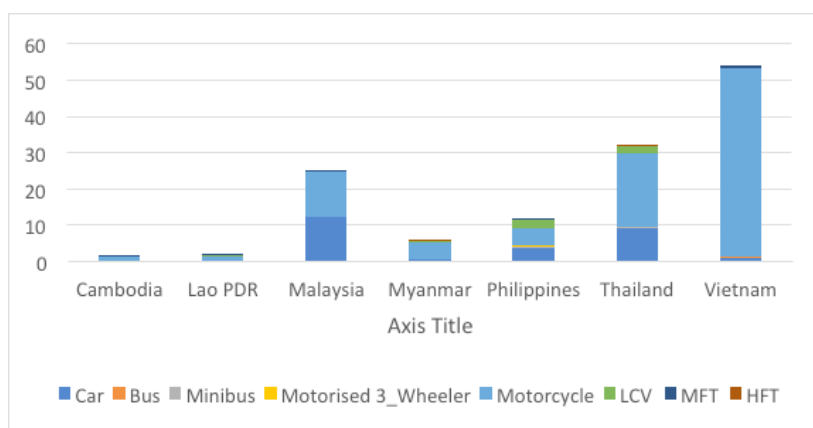


Figure 14: Total registered vehicles (millions) for sample ASEAN Countries in 2005 (Source: ITPS, 2012)

Objective and relevance The total number of vehicles on the roads is a key parameter in assessing total road energy consumption and associated emissions, and in gauging the activity and structure of road transport.

Unit of measurement This indicator is provided in terms of total number of road vehicles that are registered each year.

Methodology

Extracting data from vehicle registration databases may suffice to generate numbers of each main vehicle type, and perhaps also in terms of the fuel types. Industry data on the sales of alternative-fuel vehicles can complement the registration data, in cases where the national registry does not include such other fuels.

While all the ASEAN Member States would have vehicle registration statistics, the manner by which vehicles are categorised may not necessarily be the same. At the regional level, the ASEAN Member States are submitting data through the AJTP on vehicle stock registration using the following categories below:

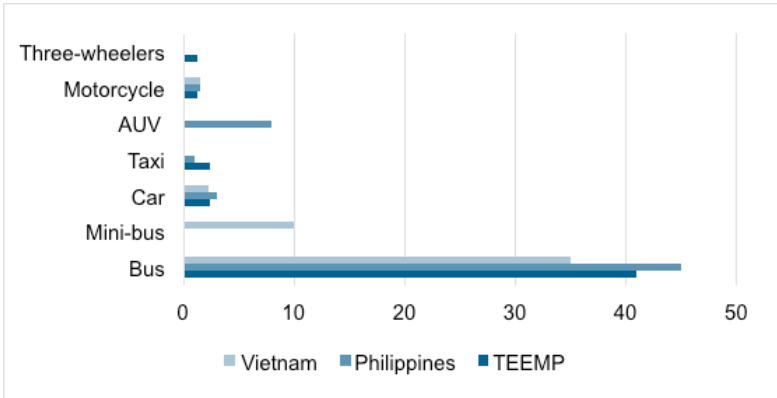
Table 7: AJTP-related definitions (Source: AJTP, 2013)

	Definition
Total number of registered road motor vehicles	The number (stock count) of road motor vehicles of all types registered in the country in a given year and licensed to use roads open to public traffic. Includes road vehicles exempted from annual taxes or license fees; imported second-hand vehicles and other road vehicles according to national practices such as tuk-tuk, tricycle, bajai, etc.. Excludes military vehicles.
Passenger cars	The number (stock count) of road motor vehicles, other than a motorcycle and the likes, intended for carriage of passengers and designed to seat no more than 9 persons (including the driver) registered in the country in a given year. This includes taxis and hired passenger cars, provided that they have fewer than ten seats, and pick-ups
Taxis and taxicabs	The number (stock count) of passenger cars registered in the country in a given year and used as a taxi or taxicab
Trucks	The number (stock count) of road motor vehicles designed, exclusively or primarily, to carry goods, regardless of size. Includes fixed-route and public trucks
Buses	The number (stock count) of road motor vehicles registered in the country in a given year primarily intended for carriage of passengers and designed to seat more than 9 persons (including the driver)
Public buses	The number (stock count) of buses registered in the country in a given year that is used for transport of one or more persons (passengers), excluding the driver, scheduled or non-scheduled, within, between and beyond built-up areas, e.g., cities, provinces or regions, etc.. Includes fixed-route city buses and fixed-route inter-city/provincial/regional buses. Excludes non-fixed route buses such as tourist buses and small share taxi buses (like "sontew"). Excludes buses used for international road transport, e.g., Malaysia-Singapore, Malaysia-Thailand, Lao PDR/Cambodia-Thailand, etc
Motorcycles	The number (stock count) of two-wheeled road motor vehicles, with or without sidecar, including motor scooter, or three-wheeled motor vehicle not exceeding 400 kg (900 lb) unladen weight such as tuktuk, bajaj, tricycle, etc. registered in the country in a given year.

In addition to the vehicle numbers, is it ideal if fuel split proportions and emission standards proportions based on the registration data can be included in the harvested data aggregates. Such information is quite useful in assigning appropriate fuel efficiencies and emission factor values. While fuel split proportions can be extracted out of national registries in a relatively straightforward manner, extracting emission standards split proportions sometimes does not prove to be easy.

Potential data sources	<p>National vehicle registries are normally within the purview of the ministries of transportation, and data is also passed on to the statistics ministries.</p> <p>Detailed vehicle sales data may also be used for consistency checks against the national registry data.</p>
Remarks	<p>While utilising existing aggregated data (and the disaggregated estimates based on categories), it is worthwhile exploring discussions on defining regional vehicle categories. For example, separating three-wheelers and utility vehicles into a separate category be useful for the ASEAN Member States. Other emerging issues, such as the rise of on-demand riding services, may also be included in the evaluation of the vehicle categories.</p>
Related indicators	<ol style="list-style-type: none"> 2. Motorisation rates 3. Total VKM travelled 4. VKM per capita 5. Total PKM by transport mode 6. Total Tonne-kilometres by transport mode 17. Total Energy Consumption by transport mode 21. Total GHG Emissions by transport mode 25. Road transport particulate matter emissions 26. Road transport NOx emissions 32. Road fatalities per million vehicles 33. Road non-fatal injuries per 10,000 vehicles

10. Average occupancies of road passenger vehicles

Section	Description																																
Description	<p>Average vehicle occupancy refers to the average number of passengers per trips for a given type of passenger vehicle. For vehicles that perform private trips, this figure includes the driver, while for public transport vehicles, the driver is not included. Occupancy rates refer to the ratio between the PKM performed and the vehicle kilometres travelled (PKM/VKM).</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="587 703 1366 1099"> <caption>Data for Figure 15: Average passenger vehicle occupancies</caption> <thead> <tr> <th>Vehicle Type</th> <th>Vietnam</th> <th>Philippines</th> <th>TEEMP</th> </tr> </thead> <tbody> <tr> <td>Three-wheelers</td> <td>~1</td> <td>~1</td> <td>~1</td> </tr> <tr> <td>Motorcycle</td> <td>~1</td> <td>~1</td> <td>~1</td> </tr> <tr> <td>AUV</td> <td>~8</td> <td>~8</td> <td>~8</td> </tr> <tr> <td>Taxi</td> <td>~2</td> <td>~2</td> <td>~2</td> </tr> <tr> <td>Car</td> <td>~3</td> <td>~3</td> <td>~3</td> </tr> <tr> <td>Mini-bus</td> <td>~10</td> <td>~10</td> <td>~10</td> </tr> <tr> <td>Bus</td> <td>~45</td> <td>~45</td> <td>~45</td> </tr> </tbody> </table>	Vehicle Type	Vietnam	Philippines	TEEMP	Three-wheelers	~1	~1	~1	Motorcycle	~1	~1	~1	AUV	~8	~8	~8	Taxi	~2	~2	~2	Car	~3	~3	~3	Mini-bus	~10	~10	~10	Bus	~45	~45	~45
Vehicle Type	Vietnam	Philippines	TEEMP																														
Three-wheelers	~1	~1	~1																														
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AUV	~8	~8	~8																														
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Car	~3	~3	~3																														
Mini-bus	~10	~10	~10																														
Bus	~45	~45	~45																														
Objective and relevance	<p>This indicator is a measure of the efficiency of passenger transport, as it provides information on how much passenger travel (PKM) is performed per unit of vehicular activity (VKM). The higher the occupancy of vehicles, the more efficient they are in terms of performing actual transportation of passengers. Average vehicle occupancy figures are also often used in estimating total PKM travelled, as most of the time, only vehicle-related activity data are available.¹⁰ It also provides information towards assisting the improvement of travel demand management interventions, and public transport services.</p>																																
Unit of measurement	<p>This is reported in terms of <u>average number of persons per passenger vehicle</u>.</p>																																

Methodology There are several methods of generating average vehicle occupancy data, including field observation techniques, image processing, calculation based on available seats (buses), accident database extraction methods, and mail out or electronic surveys for private vehicles (Heaidman, et al., 1997). The equation below defines the average occupancy as a function of empirically observed passenger-kilometre and vehicle-kilometre values.

$$AO_x = \frac{PKM_x}{VKM_x}$$

Where:

AO_x = average occupancy of road passenger vehicle x
(persons/vehicle)

PKM_x = total PKM performed by road passenger vehicles
type x (PKM)

VKM_x = total vehicle-kilometres (VKM) by road passenger
vehicle type x

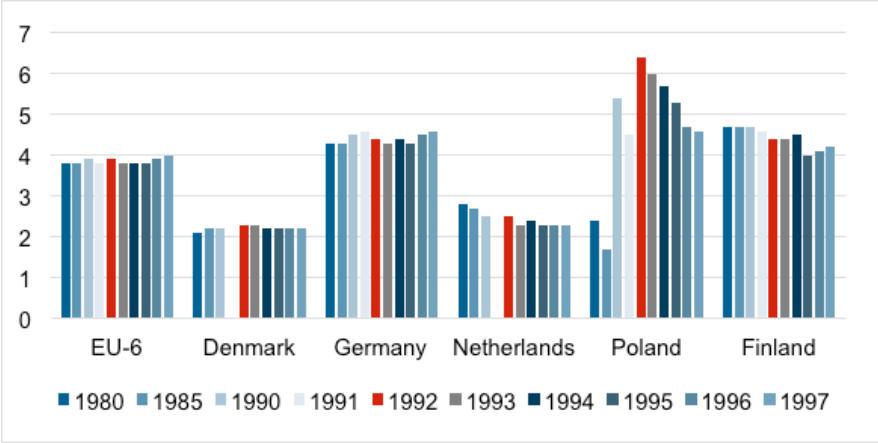
x = road passenger vehicle types

Potential data sources Urban transport studies, or industry-generated data (i.e. for public transport vehicles) are potential sources of data. Ministries of transportation would also handle data that is relevant to this indicator.

Remarks Average occupancy values taken from site-specific surveys may not necessarily be representative of the population's average, but these may be good enough surrogates for enabling relevant analysis.

Related indicators 5. Total PKM by transport mode
17. Total energy consumption by transport mode

11. Average loads of road freight vehicles

Section	Description
Description	<p>This indicator is defined as the average weight of loads carried by freight vehicles per trip (EEA, 2001).</p> <p><i>Illustrative example</i></p>
	 <p>Figure 16: Average load in sample EU countries (Source: EEA, n.d.)</p>
Objective and relevance	<p>Freight vehicle load factors are measures of freight transport efficiencies, as they provide insights into how much of the total capacity of the freight vehicle fleet is being used. Increasing load capacities to optimal levels can reduce the growth in freight VKM, as the need to add more vehicles is mitigated through the utilisation of the existing vehicle capacities.</p>
Unit of measurement	<p>This indicator is reported in terms of <u>average tonnes carried/vehicle</u>.</p>

Methodology

Load factors for freight vehicles are calculated based on surveys (e.g. commodity flow surveys, operator surveys or roadside surveys), or through data from weigh bridges. The Eurostat reference manual, for example, lays out guidelines on the conduct of road freight surveys, with the aim of generating data about the work done (transportation of goods), including data on the journeys, vehicles, and enterprises. The guidelines are based on agreements at the regional level (EU), and enterprises are randomly selected for participation in the survey, depending on the type of sampling design deemed appropriate by the country, based on budget, and with the aim of minimising errors.¹¹

The surveys include the collection of enterprise data (e.g. type of company, operations, or fleet size), vehicle, and journey-related data. The vehicle data includes parameters such as: age of the vehicle; type and amount of fuel purchased during survey period; body type of the vehicle and the trailer or semi-trailer; and total kilometres covered during the survey period. The provision of detailed vehicle data is encouraged as well, e.g. make and model. The data collected for the journeys include details about the stages, as freight trucks can make multiple stops while delivering goods. Details about the spatial movements are also collected, including the first place of loading and last place of unloading, any countries crossed in transit, and any other places of loading or unloading. Data on the goods carried are collected as well such as the types of goods carried based on a standard classification, the weight of goods carried, the cargo type¹² and the distance travelled (Eurostat, 2011).

The generated data on total tonne-kilometres are then divided by the estimated total VKM to get the average load (tonne-kilometre/ vehicle kilometre).

$$AL_y = \frac{TKM_y}{VKM_y}$$

Where:

- AL_y = average load of road freight vehicle i (tonne/ vehicle)
- TKM_y = tonne-kilometres performed by road freight vehicle type y (TKM)
- VKM_y = total vehicle-kilometres (VKM) by road freight vehicle y
- y = road freight vehicle types

Potential data sources

Freight-related studies or industry data are potential sources of information. Data from weigh bridges can also provide insights but are only reflective of loads at the specific locations.

Remarks	Average loading values taken from site-specific data may not necessarily be representative of the population's average, but may nonetheless be good enough surrogates to enable relevant analysis.
Related indicators	7. Total tonne-kilometres by transport mode

12. Alternative-fuel vehicle as a proportion of the road vehicle fleet

Section	Description
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Description This indicator quantifies the penetration of alternative-fuel vehicles in the vehicle fleet.

Illustrative example

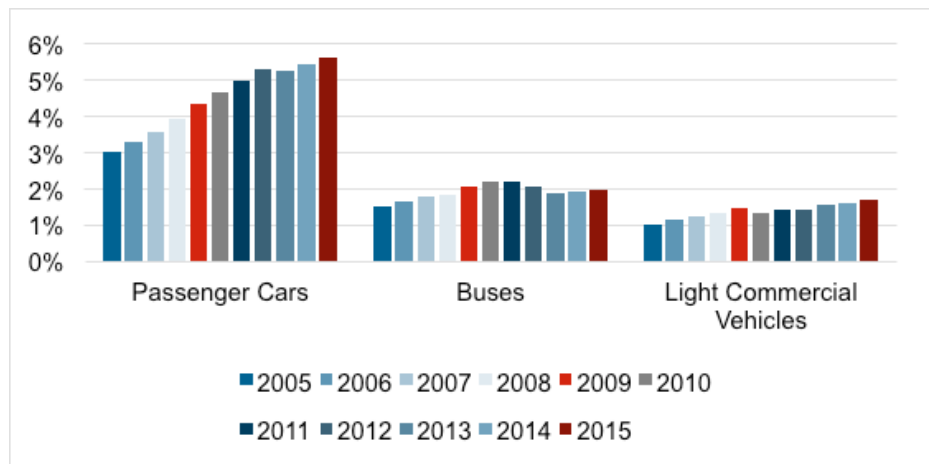


Figure 17: Alternative-fuel vehicles as a proportion of vehicles by vehicle types (Source: EEA, n.d.)

Objective and relevance	This indicator quantifies the penetration of alternative-fuel vehicles in the fleet and can be used in assessing progress against related targets. ¹³ Historically, several ASEAN Member States have stated internal or international targets that relate to the promotion of alternative-fuel powered vehicles.
Unit of measurement	This indicator is given in terms of the percentage <u>of vehicles</u> within the vehicle fleet and vehicle types that run on alternative fuel. 'Alternative-fuel vehicles' is a term normally used for vehicles that are not powered by petrol (gasoline) or diesel. The EU, for example, considers liquefied petroleum gas (LPG), natural gas (NG), and electric vehicles as subsets of alternative-fuel vehicles.

Methodology	<p>This proportions are calculated by dividing the number of alternative-fuel vehicles by the total population of vehicles. This can be done for each of the vehicle types as well.</p> $PAV = \frac{AV}{VehPop}$ <p>PAV = proportion of all vehicles that are alternative-fuel road vehicles (%) AV_i = number of alternative-fuel road vehicles VehPop = total road vehicle population</p>
Potential data sources	<p>Numbers taken from vehicle registration databases can approximate real conditions. However, not all registration databases have been updated to account for alternative-fuel vehicles, e.g. official statistics may only account for diesel, and gasoline vehicles. Industry data (e.g. sales estimates) can be used in order to approximate proportions, but calculation methods also need to consider other factors, such as vehicle retirement.</p>
Remarks	<p>While the proportion of alternative-fuel vehicles provides indications on the structure of the vehicle fleet, the insights from these indicators do not necessarily translate directly to insights regarding the environmental or energy performance of the fleet. For electric vehicles, for example, it is quite important to take into consideration the sources of power.</p> <p>It might also be worthwhile investigating the percentage that alternative-fuel vehicles represent among all vehicles sold, as well as among each vehicle type.</p>
Related indicators	<p>9. Total road vehicles 17. Total energy consumption by transport mode 21. Transport GHG emissions by transport mode 25. Road transport particulate matter emissions 26. Road transport NOx emissions</p>

13. Renewable energy as share of total energy consumption, by transport mode

Section	Description
Description	This indicator refers to the percentage share of renewable sources to the total energy consumed by each transport mode.
Objective and relevance	This indicator provides insights into the structure of the transportation modes in terms of energy sources and is useful in gauging the level of dependence of a country's transportation system on fossil fuels, and how it maximises the use of renewable energy in the transport sector.
Unit of measurement	This indicator is given in terms of the <u>percentage of total energy consumed</u> by road and rail transport that is generated from renewable energy sources. Separate figures are to be provided for <u>road and rail</u> .
Methodology	<p>Final energy consumption can be defined as the consumption of energy not related to fuel conversion or transformation (IEA, 2005). Renewable energy can be defined simply as energy derived from natural processes that are constantly replenished (IEA, 2005). Eurostat defines the following as renewable sources of energy: hydropower; tide, wave, ocean; geothermal; wind; solar; biofuels; fuels from biomass; and renewable municipal waste.¹⁴</p> <p>In practical terms, this indicator can be derived from the Overall Energy Balance (OEB) sheets of the country. The OEB provides information on the estimated energy supply and its transformation, and the energy consumption by various sectors, e.g. transportation. The OEB can directly provide information on the usage of primary renewable fuels (e.g. biofuels) that are directly used in transport. However electricity produced from such renewable fuels, which qualifies as secondary renewable energy, is not directly disaggregated in the final consumption statistics. But the proportion of this energy consumed can be calculated where data is available on the proportion of the overall energy supply that is derived from renewables.</p>

$$RETE_z = \left(\frac{\left(RE_z + (GEC_z * \left(\frac{GRE}{TGE} \right)) \right)}{TTE_z} \right)$$

Where:

$RETE_z$ = Renewable energy share (%) in total energy consumed by mode z

RE_z = renewable (e.g. biofuels) energy consumption by transport mode z (Joule)

GEC_z = Grid electricity consumption by mode z (Joule)

GRE = Grid electricity generated by renewable energy sources (Joule)

TGE = Total grid electricity generation (Joule) transport sector (Joule)

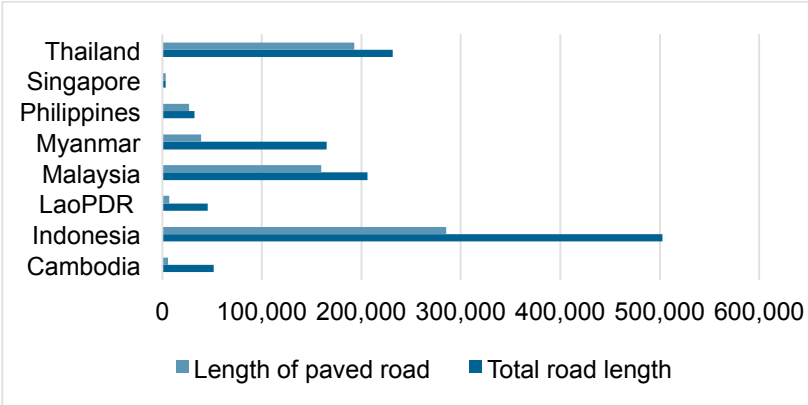
TTE_z = Total transport energy consumption (Joule) for mode z

z = transport modes (e.g. road, rail)

$*$ = multiplication

Potential data sources	The ministries or departments of energy would be the primary source of the Overall Energy Balance tables.
Remarks	Monitoring the share of renewable energy directly consumed in the transport sector can provide indications of the sustainability of the sector. It would be ideal if the renewable share of the underlying energy sources (e.g. the primary source of grid electricity) were also monitored and contextualised.
Related indicators	17. Total energy consumption by transport mode

14. Kilometres of road and rail infrastructure

Section	Description																											
Description	<p>This indicator provides available information total length of road and rail infrastructure.</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="531 555 1342 958"> <caption>Data for Figure 18: Total kilometres of roads</caption> <thead> <tr> <th>Country</th> <th>Length of paved road (km)</th> <th>Total road length (km)</th> </tr> </thead> <tbody> <tr> <td>Thailand</td> <td>~180,000</td> <td>~220,000</td> </tr> <tr> <td>Singapore</td> <td>~10,000</td> <td>~10,000</td> </tr> <tr> <td>Philippines</td> <td>~30,000</td> <td>~30,000</td> </tr> <tr> <td>Myanmar</td> <td>~50,000</td> <td>~180,000</td> </tr> <tr> <td>Malaysia</td> <td>~150,000</td> <td>~200,000</td> </tr> <tr> <td>LaoPDR</td> <td>~20,000</td> <td>~50,000</td> </tr> <tr> <td>Indonesia</td> <td>~300,000</td> <td>~500,000</td> </tr> <tr> <td>Cambodia</td> <td>~20,000</td> <td>~50,000</td> </tr> </tbody> </table>	Country	Length of paved road (km)	Total road length (km)	Thailand	~180,000	~220,000	Singapore	~10,000	~10,000	Philippines	~30,000	~30,000	Myanmar	~50,000	~180,000	Malaysia	~150,000	~200,000	LaoPDR	~20,000	~50,000	Indonesia	~300,000	~500,000	Cambodia	~20,000	~50,000
Country	Length of paved road (km)	Total road length (km)																										
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Cambodia	~20,000	~50,000																										
	<p>Figure 18: Total kilometres of roads (Source: AJTP database)</p>																											
Objective and relevance	<p>The availability of information on transport infrastructure allows for the analysis of the capacity of the system to handle existing and future transport activity. At the macro level, the availability of such an indicator allows for benchmarking of efficiencies, i.e. how much activity is being performed given a certain amount of infrastructure. It also provides for a better understanding of the need for strengthening certain modes by investing in more infrastructure to enable growth of these capacities, e.g. public transport.</p>																											
Unit of measurement	<p>This indicator is provided in units of length, normally in <u>total kilometres of all roads and railways</u>. Separate figures are to be provided for <u>road and rail</u>.</p>																											
Methodology	<p>Transportation infrastructure data is normally collected and consolidated through a bottom-up process wherein relevant data collection processes, such as detailed road inventories, are conducted and the data aggregated. Countries in ASEAN utilise road classification systems based on functions including context (e.g. urban or rural), or based on administrative categories, or on physical characteristics (e.g. paved or unpaved), or a combination of these.</p> <p>Network length indicators can be combined with activity indicators to generate activity-to-infrastructure efficiency ratios.</p>																											

Potential data sources	<p>Official estimates in terms of total lengths of roads and railways under different classifications are normally available in ASEAN countries, primarily through the ministries responsible for infrastructure. Aggregated network lengths are included in the ASEAN Statistical Yearbook. Alternatively, infrastructure characteristics can be estimated using information from platforms based on geographical information systems (GIS), such as crowd-sourcing platforms that generate information on national, regional, and local bicycle networks.¹⁵</p>
Remarks	<p>To maximise the utility of a regional database on transportation infrastructure indicators, it would be worthwhile to collect data that would contain more detailed information that would provide for insights on the availability of infrastructure that are sub-classified (not just total lengths of road networks, for example). This has already been achieved for classification of highways, as ASEAN already has the ASEAN Standard of Highway Classification.¹⁶</p> <p>From an energy and energy standpoint, the availability of network data based on functional classifications would be useful. Moreover, the availability of information on the dedicated infrastructure for efficient transport modes, such as cycleways and dedicated bus lanes, would be ideal.</p>
Related indicators	None

15. Average road vehicle fuel economy

Section	Description
Description	<p>Average vehicle fuel economy is an indicator of the amount of fuel consumed for travelling a unit of distance by a vehicle.</p> <p>Initiatives are already monitoring the progression of the average vehicle fuel economy of fleets, particularly those of light-duty vehicles. The Global Fuel Economy Initiative (GFEI), for example, estimates that light-duty vehicle fleets in countries of the Organisation for Economic Co-operation and Development consume 6.9 litres of gasoline equivalent per kilometre (LGE/km) in 2013, while those from non-OECD countries consume 7.2 LGE/km (GFEI, 2016).</p>
Objective and relevance	<p>This is a measure of the average efficiencies of vehicles in a certain fleet and reflects the amount of fuel or energy needed per VKM. It provides insights that are needed for interventions towards improving the energy efficiencies of the future vehicle fleets, such as: fuel economy standards for new vehicles; fuel economy labelling; or incorporating fuel economy considerations in vehicle taxation or incentive schemes.</p>
Unit of measurement	<p>This indicator is normally reported in the ASEAN region as KVM per unit of fuel. However, for the purposes of aligning with global nomenclature, it can be reported in terms of <u>litres of gasoline equivalent per 100 kilometres</u>.</p>
Methodology	<p>Average fuel economy values are weighted averages of the fuel economy values associated with the different segments of the vehicle fleet. If detailed data is available on the numbers for each vehicle model, year, type and fuel, this can be used in conjunction with the fuel economy ratings that are provided by the manufacturers. Aside from data from the vehicle registry, vehicle sales data can also be used to calculate the average fuel economy of the vehicle fleet (or vehicle segments).</p> <p>In ASEAN, local vehicles are often customised, and these most often do not undergo fuel economy tests. Average fuel economy values are normally based on specific studies that conduct either on-road or laboratory fuel economy tests using drive cycles that mimic real-world conditions.</p> <p>The equation below shows the calculation of average fuel economy values used by the Global Fuel Economy Initiative (GFEI), primarily for evaluating averages for new entrants to the vehicle fleet. This can be used in evaluating the average fuel economy of the vehicle segments in the stock, by replacing sales with the known number of total registrations if available.</p>

$$Fuel\ economy_k = \left(\frac{total\ sales_k}{\sum \left(\frac{sales\ model_m}{fuel\ economy\ model_m} \right)} \right)$$

- Fuel Economy_k = fuel economy (LGE (litres of gasoline equivalent/100 km) of vehicle segment k which are new entrants to the market
- Sales model_m = total sales of model m
- Fuel economy model_m = rated fuel economy of model m (converted to LGE/100 km)
- k = vehicle segment of interest (e.g. light-duty vehicles, etc.)
- m = models belonging to vehicle segment k

The conversion factors for normalising volumetric fuel economy values to LGE per 100 km are provided below (GFEI website):

- diesel: 1.08
- CNG: 1.12
- LPG: 1.15

It is also important to note that published fuel economy values by the manufacturers are based on different driving cycles and these need to be converted into common values. The table below depicts the proposed conversion factors (UNEP, 2018).¹⁷

Table 8: Conversion factors for different drive cycles to NEDC

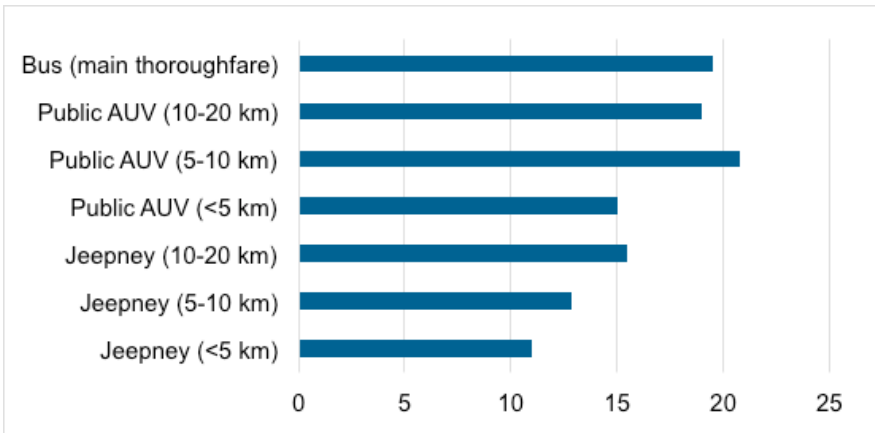
Gasoline	unit: gCO ₂ per km	CAFE to NEDC	NEDC	=	1.1325	*	CAFE	-	13.739
		JC08 to NEDC	NEDC	=	0.8457	*	JC08	+	24.840
Diesel	unit: gCO ₂ per km	CAFE to NEDC	NEDC	=	1.2209	*	CAFE	-	21.218
		JC08 to NEDC	NEDC	=	0.8230	*	JC08	+	21.950

Potential data sources

If detailed segmented information is accessible from the vehicle registry, the vehicle numbers can be matched with the appropriate fuel economy values that are made available, for example that provided by the US fueleconomy.gov website. The GFEI also provides detailed methodologies for calculating baseline fuel economy values, as well as computed averages for light-duty vehicles for selected countries (see <https://www.globalfueleconomy.org/in-country/gfei-toolkit>). There are also available studies in the ASEAN Member States for different vehicle types, but these are normally computed based on samples.

Remarks	The use of declared fuel economy values from the vehicle manufacturers enables the incorporation of the differences of the individual vehicle models in terms of efficiencies. However, there is a gap between tested fuel economy values and on-road values. There are many factors that can result in such gaps, and recent evidence suggests that the gaps between on-road and posted fuel economy estimates have been increasing. ¹⁸
Related indicators	17. Total energy consumption by transport mode 21. Total GHG emissions by transport mode

16. Average road vehicle speeds

Section	Description																
<p>Description</p> <p>This refers to the average speed of vehicles in a given driving condition or geographic area.</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="464 562 1342 992"> <caption>Data for Figure 19: Average Vehicle Speeds in Metro Manila, Philippines</caption> <thead> <tr> <th>Vehicle Type / Distance</th> <th>Average Speed (km/hour)</th> </tr> </thead> <tbody> <tr> <td>Bus (main thoroughfare)</td> <td>~19</td> </tr> <tr> <td>Public AUV (10-20 km)</td> <td>~19</td> </tr> <tr> <td>Public AUV (5-10 km)</td> <td>~21</td> </tr> <tr> <td>Public AUV (<5 km)</td> <td>~15</td> </tr> <tr> <td>Jeepney (10-20 km)</td> <td>~15</td> </tr> <tr> <td>Jeepney (5-10 km)</td> <td>~13</td> </tr> <tr> <td>Jeepney (<5 km)</td> <td>~11</td> </tr> </tbody> </table>	Vehicle Type / Distance	Average Speed (km/hour)	Bus (main thoroughfare)	~19	Public AUV (10-20 km)	~19	Public AUV (5-10 km)	~21	Public AUV (<5 km)	~15	Jeepney (10-20 km)	~15	Jeepney (5-10 km)	~13	Jeepney (<5 km)	~11	<p>Figure 19: Average Vehicle Speeds in Metro Manila , Philippines (Source: JICA, 2007)¹⁹</p>
Vehicle Type / Distance	Average Speed (km/hour)																
Bus (main thoroughfare)	~19																
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Jeepney (10-20 km)	~15																
Jeepney (5-10 km)	~13																
Jeepney (<5 km)	~11																
<p>Objective and relevance</p>	<p>At the micro level, traffic speeds are useful in evaluating the effectiveness of traffic interventions (e.g. speed limits), specific design applications, and traffic signal settings, among others. At the macro level, average speeds are important in assessing the temporal efficiency of transportation, and whether the state of mobility is improving or worsening. Generalised speeds are also used in assessing energy consumption, and emissions, as those are impacted by the speeds of the vehicles.</p>																
<p>Unit of measurement</p>	<p>Average speeds are reported in terms of <u>km/hour</u>.</p>																
<p>Methodology</p>	<p>At the micro level, average speed data can be generated from devices such as induction loop detectors installed on motorways, Bluetooth sensors, GPS devices, or remote sensing equipment. They can also be calculated as a function of vehicle flow (vehicle/hour) divided by the vehicle density (vehicle/km). Such data can be aggregated in order to get a sense of conditions in a certain area.</p> <p>For aggregated speed indicators, available data for different vehicle segments can be used for relevant applications such as emissions inventories, or energy efficiency studies where interventions can lead to changes in average speeds, and thus impact emissions or energy consumption. Representative values estimated to reflect differences in average speeds between different geographical categories (e.g. urban or non-urban driving), are normally used.</p>																

Potential data sources	Area-specific transportation studies containing observed and modelled speeds are useful references. Transportation ministries should have some information on estimates based on such studies.
	Other sources of information include travel (passenger and freight) surveys, as one can potentially use data on start and end times for trips and trip distances to calculate speeds that can then be related to certain vehicle types. Also, the advent of mobile phone GPS technology is now enabling the generation of massive data on transportation, including average speeds.
Remarks	Aggregating average speeds (e.g. from specific corridors to an urban area, or assuming a value for a country) may not properly reflect real conditions, but having reasonable values are quite important in enabling interventions on improving transport efficiencies.
Related indicators	Average speeds can be used in bottom-up estimation of energy consumption, as well as GHG and air pollutant emissions. 17. Total energy consumption by transport mode 25. Road transport particulate matter emissions 26. Road transport NOx emissions

17. Total energy consumption by transport mode

Section	Description
Description	This indicator refers to the final energy consumed by the transportation sector within a specified period.

Illustrative example

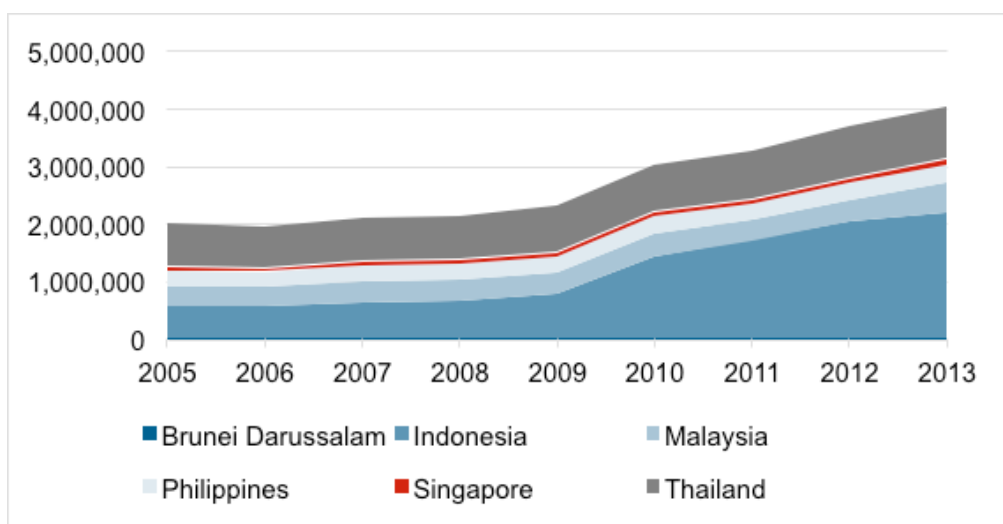


Figure 20: Road transport energy consumption (TJ) in Selected ASEAN countries (Source: IEEJ)

Objective and relevance	This indicator is meant to keep track of the total energy consumption of the transport sector. It is also critical to have robust estimates of fossil fuel consumption if the emissions inventories are to be accurate. In road transport, it is often the case that gasoline- and diesel-fired vehicles comprise a very significant share of the CO ₂ emissions, for example. For rail, it is important to account for electricity consumption and the characteristics of the source grids.
Unit of measurement	This indicator is reported in terms of <u>terajoules per year (TJ/year)</u> . Fuel consumption data is normally collected in terms of the fuel-specific unit of consumption (e.g. litres, tonne, kg), and must be transformed into energy units using the appropriate conversion factors. ²⁰ It is suggested by these Guidelines that total energy consumption be provided or calculated separately for road and rail transport.

Methodology

Fuel consumption estimates can either be based on the national estimates that are usually available from the energy ministries/departments (energy balance sheets), or be based on a bottom-up, activity-based estimation process.

The official fuel consumption data are contained in the official energy balance sheets, which essentially converts estimated fuel consumption (based on fuel sales) into energy units. For a detailed explanation of the methodology for calculating the final energy consumption based on a top-down approach, please refer to IEA (2009).

Activity-based fuel consumption estimates are normally based on the equation below, although the level of complexity in estimating the input parameters may vary depending on the data available. This approach is also sometimes called a bottom-up approach, as one is estimating aggregate values from smaller components (e.g. vehicles). The equation below shows the calculation of such for fossil fuel-powered road vehicles:²¹

$$EC_z = \sum_a \left((Vehicle_{i,a} * VKM_{i,a} * FE_{i,a}) * Calorific Value_a \right)$$

EC_z = bottom-up estimate of energy consumption for mode z

$Vehicle_{i,a}$ = number of vehicle type i using fuel a

$VKM_{i,a}$ = average vehicle kilometres performed by vehicle type i using fuel a

$FE_{i,a}$ = average fuel economy (expressed as kg fuel/km) of vehicle type i using fuel a

$Calorific value_a$ = calorific value or the quantity of heat produced during combustion for fuel a (kJ/kg)²²

i = vehicle types under transport mode z

z = transport modes (e.g. road, rail)

a = fuel types

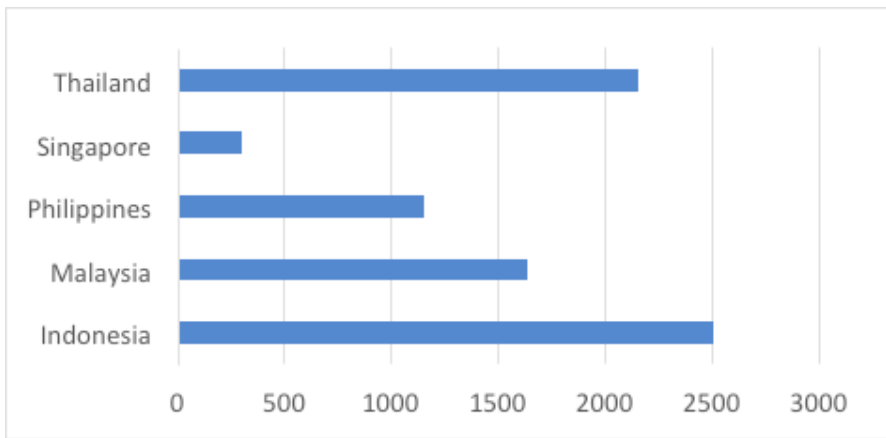
* = multiplication

Potential data sources

The data parameters needed in for top-down calculations for this indicator are normally found in a country's Overall Energy Balance (OEB), which provides energy consumption statistics for the different consumption sectors (including transport), and, under transportation, provides estimated consumption for each major mode (e.g. road, rail, water or air). Data sources for the bottom-up parameters can be found in the other factsheets (see the section below on relevant indicators).

Remarks	<p>Although the official national energy balance sheets contain estimates of fuel consumption in the transportation sector that can be used for top-down estimates, these are normally disaggregated only for a certain level (e.g. road, rail, international aviation, domestic aviation, domestic navigation, or pipeline transport). Moreover, estimates may also be influenced by limitations in data collection. For example, one can reasonably assume that in many of the developing countries in ASEAN, a certain percentage of the fuels being bought from fuel stations are being used for purposes other than transport (e.g. agriculture or stationary equipment), but this may not be truly reflected in the data, as the managers of the fuel stations have no incentive to accurately report this. Moreover, fuel smuggling can undermine the integrity of any aggregated energy consumption estimates.</p> <p>Comparing activity-based estimates (using vehicle population and vehicle energy efficiencies), with fuel sales-based estimates is useful as it can point towards potential discrepancies which can provide useful insights to the validity of both estimates.</p>
Related indicators	<ul style="list-style-type: none"> 3. Total road VKM travelled 9. Total road vehicles 15. Average road vehicle fuel economy 18. Energy consumption per GDP by transport mode 21. Total GHG emissions by transport mode

18. Energy consumption per GDP by transport mode

Section	Description												
Description	<p>This indicator can be defined as the ratio between the consumption of energy in transport and the economy. It compares the growth of the transport sector's energy consumption with that of GDP.²³</p> <p>The figure below provides some sense of the range of values for such an indicator, specifically for road transport. The values are based on current GDP taken from the ASEANStat website, and the 2013 road transport energy consumption estimates based on IEEJ (n.d.).</p> <p><i>Illustrative example</i></p>  <table border="1"> <caption>Data for Figure 21: Road transport energy consumption per GDP (kilojoule/GDP)</caption> <thead> <tr> <th>Country</th> <th>Energy consumption per GDP (kilojoule/GDP)</th> </tr> </thead> <tbody> <tr> <td>Thailand</td> <td>~2100</td> </tr> <tr> <td>Singapore</td> <td>~300</td> </tr> <tr> <td>Philippines</td> <td>~1100</td> </tr> <tr> <td>Malaysia</td> <td>~1600</td> </tr> <tr> <td>Indonesia</td> <td>~2500</td> </tr> </tbody> </table> <p>Figure 21: Road transport energy consumption per GDP (kilojoule/GDP) (Source: ASEANStat and IEEJ data)²⁴</p>	Country	Energy consumption per GDP (kilojoule/GDP)	Thailand	~2100	Singapore	~300	Philippines	~1100	Malaysia	~1600	Indonesia	~2500
Country	Energy consumption per GDP (kilojoule/GDP)												
Thailand	~2100												
Singapore	~300												
Philippines	~1100												
Malaysia	~1600												
Indonesia	~2500												
Objective and relevance	<p>This indicator is useful in generating insights regarding the transport energy-intensity of the economy. In essence, it depicts how much energy is spent on transportation activities in order to generate a unit of GDP. It is an important indicator for measuring the effectiveness of energy-efficiency measures at the macro-level in delivering the desired efficiency gains.</p>												
Unit of measurement	<p>This indicator is reported in terms of energy units per GDP (<u>kilojoule/GDP</u>). These Guidelines suggest that separate values for <u>road and rail</u> transport be provided or calculated</p>												
Methodology	<p>This indicator can be calculated by dividing the total fuel consumption of the road transport sector by the total GDP (see Factsheets 17 and 27).</p> $ECGDP_z = \frac{EC_z}{GDP}$ <p>Where:</p> <ul style="list-style-type: none"> $ECGDP_z$ = transport energy consumption per unit of GDP for mode z (kilojoule/USD) EC_z = energy consumption of transport mode z (kilojoules) GDP = gross domestic product (in USD) z = transport modes (e.g. road, rail) 												

Potential data sources	The data parameters needed to calculate this indicator are normally found in national statistics. The Overall Energy Balance (OEB) of a country would provide energy consumption statistics for the different consumption sectors (including transport), and under transportation, estimated consumption for each major mode are provided (e.g. for road, rail, water and air). These figures can be divided by constant GDP in order to generate this indicator. For further information, please see Factsheets 17 and 27.
Remarks	This indicator is crucial in tracking the progress of countries in terms of the efficiency of transportation, in relation to the economy. The interpretation of this indicator requires that the structure of the economy be taken into consideration, particularly if countries are to be compared. Converting the values into indices (with a specific year as the base) would be useful for individual countries for tracking their progress.
Related indicators	17. Total energy consumption by transport mode 27. Gross domestic product

19. Particulate matter emission factors of road vehicles

Section	Description
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Description

Emission factors reflect the rate at which a certain vehicle (or vehicle segment) emits a certain pollutant per unit of activity (VKM). Particulate matter (PM) has been implicated as the most critical road transport sector pollutant due to the well documented impacts of PM on human health, the relative contribution of the transport sector in the PM emissions and the proximity of the sources (vehicles) to the human population, particularly in urban areas (Gorham, 2002).

Illustrative example

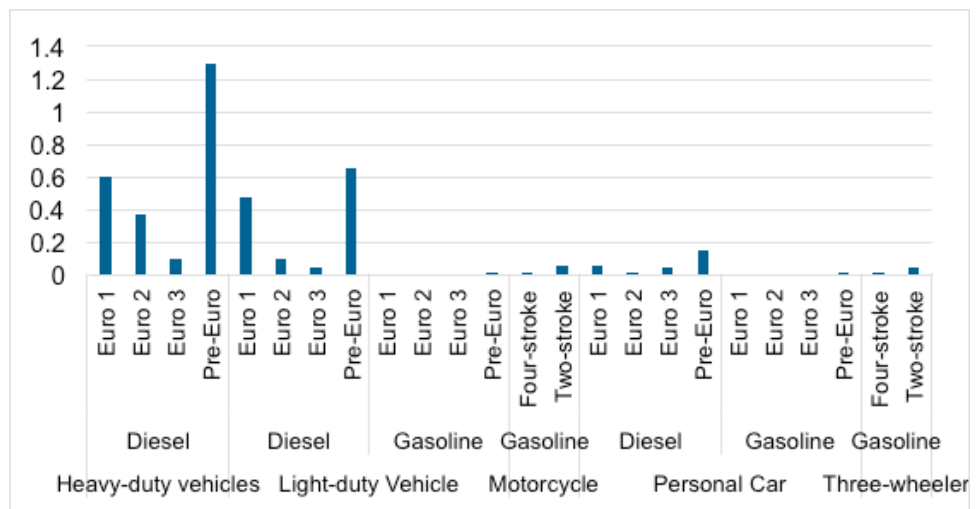


Figure 22: Example PM emission factors (gramme/VKM) (Source: Clean Air Asia, 2012)

Objective and relevance

Emission factors provide information on how polluting a certain vehicle segment is. These are particularly useful when different segments are compared. Vehicle emission factors are used in conducting emissions inventories for mobile sources, as well as in evaluating the impacts of emission reduction interventions that are related to vehicle and fuel technologies, and operations.

Unit of measurement

Vehicle emission factors are provided in terms of the amount or weight of pollutant emitted per vehicle activity (gramme/vehicle-kilometre) per vehicle type.

Methodology	<p>Emission factors are assessed primarily through laboratory or on-road tests that use emission analysers. Emission factor models enable the adjustment of base vehicle emission factors to reflect the impact of local conditions (e.g. fuel quality, operating conditions, inspection and maintenance and temperature), as well as drive cycles. These models can also be used for generating emission factors that approximate real-world conditions, albeit limited by the available information and the limitations of such models.</p> <p>A practical approach is to adopt locally calibrated base emission factors for each vehicle type-fuel type-emission standard vehicle bins, and use estimated proportions for the local vehicle fleet to arrive at weighted emission factors for each vehicle type. Updates can be based on changes in the composition of the fleet without the need to update the base emission factors.</p>
Potential data sources	<p>Vehicle emission factor studies that include PM for local vehicles have been conducted in some of the countries in ASEAN. These are primarily conducted by expert institutions and laboratories, as well as academic institutions as well. Locally adjusted vehicle emission rates are also available from the ministries of environment for some of the countries in ASEAN. Emission factor databases from international sources are also available. Other international databases include the following: EMEP/EEA air pollutant emission inventory guidebook - 2016; Air Pollutant Emission Factor Library; international vehicle emissions model (IVE) ; and the Transport emissions evaluation model for projects (TEEMP).</p>
Remarks	<p>In many cases, vehicle emissions inventories and related initiatives in the region use adjusted or even non-adjusted emission factors from other countries. The use of these must recognise that they need to be adjusted to local conditions, and that even the adjusted values may not necessarily properly approximate real-life conditions. For more information about particulate matter, see Factsheet 25.</p>
Related indicators	25. Road transport particulate matter emissions

20. NOx emission factors of road vehicles

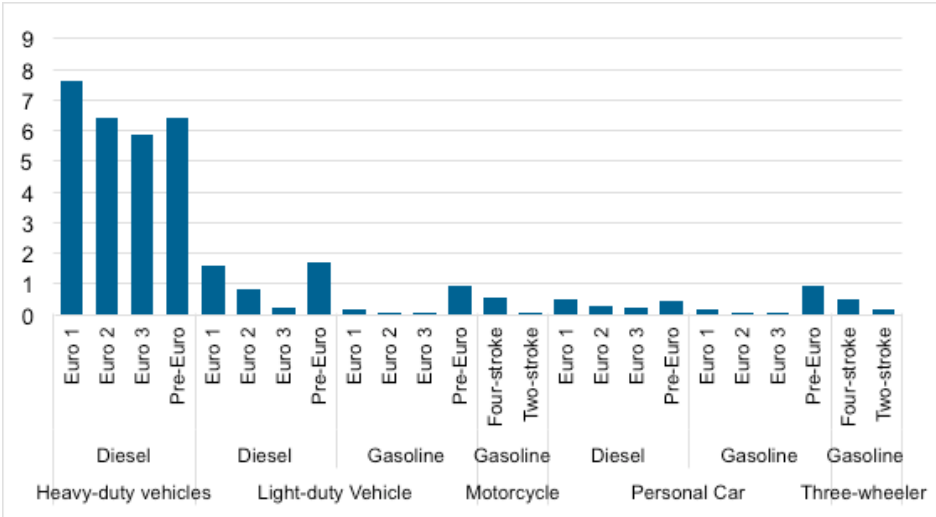
Section	Description																																														
Description	<p>Emission factors reflect the rate at which a certain vehicle (or vehicle segment) emits a certain pollutant per unit of activity (VKM). Oxides of Nitrogen (NOx) are one of the most critical pollutants from transportation, particularly from road vehicles, and have been implicated in negative impacts on the environment and human health. Reducing NOx is important in terms of both health and environment. NOx emissions contribute to lung damage and respiratory function impairment such as bronchitis and emphysema, as well as the exacerbation of heart disease. Nitrous oxide (N₂O), a compound within the category of NOx, is also a potent greenhouse gas, and has a global warming potential of 310 Carbon dioxide equivalent as per the IPCC.</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="501 909 1441 1424"> <caption>Approximate NOx emission factors (gramme/VKM) from Figure 23</caption> <thead> <tr> <th>Vehicle Segment</th> <th>Standard</th> <th>Emission Factor (gramme/VKM)</th> </tr> </thead> <tbody> <tr> <td rowspan="4">Heavy-duty vehicles (Diesel)</td> <td>Euro 1</td> <td>7.5</td> </tr> <tr> <td>Euro 2</td> <td>6.5</td> </tr> <tr> <td>Euro 3</td> <td>6.0</td> </tr> <tr> <td>Pre-Euro</td> <td>6.5</td> </tr> <tr> <td rowspan="4">Light-duty Vehicle (Diesel)</td> <td>Euro 1</td> <td>1.8</td> </tr> <tr> <td>Euro 2</td> <td>1.0</td> </tr> <tr> <td>Euro 3</td> <td>0.5</td> </tr> <tr> <td>Pre-Euro</td> <td>1.8</td> </tr> <tr> <td rowspan="3">Motorcycle (Gasoline)</td> <td>Euro 1</td> <td>0.5</td> </tr> <tr> <td>Euro 2</td> <td>0.2</td> </tr> <tr> <td>Euro 3</td> <td>0.1</td> </tr> <tr> <td rowspan="4">Personal Car (Diesel)</td> <td>Pre-Euro</td> <td>1.0</td> </tr> <tr> <td>Four-stroke</td> <td>0.8</td> </tr> <tr> <td>Two-stroke</td> <td>0.2</td> </tr> <tr> <td>Euro 1</td> <td>0.5</td> </tr> <tr> <td rowspan="4">Three-wheeler (Gasoline)</td> <td>Euro 1</td> <td>0.5</td> </tr> <tr> <td>Euro 2</td> <td>0.2</td> </tr> <tr> <td>Euro 3</td> <td>0.1</td> </tr> <tr> <td>Pre-Euro</td> <td>1.0</td> </tr> </tbody> </table>	Vehicle Segment	Standard	Emission Factor (gramme/VKM)	Heavy-duty vehicles (Diesel)	Euro 1	7.5	Euro 2	6.5	Euro 3	6.0	Pre-Euro	6.5	Light-duty Vehicle (Diesel)	Euro 1	1.8	Euro 2	1.0	Euro 3	0.5	Pre-Euro	1.8	Motorcycle (Gasoline)	Euro 1	0.5	Euro 2	0.2	Euro 3	0.1	Personal Car (Diesel)	Pre-Euro	1.0	Four-stroke	0.8	Two-stroke	0.2	Euro 1	0.5	Three-wheeler (Gasoline)	Euro 1	0.5	Euro 2	0.2	Euro 3	0.1	Pre-Euro	1.0
Vehicle Segment	Standard	Emission Factor (gramme/VKM)																																													
Heavy-duty vehicles (Diesel)	Euro 1	7.5																																													
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Objective and relevance	<p>Emission factors provide information on how polluting a certain vehicle segment is. These are particularly useful when the segments are compared with each other. Vehicle emission factors are used in conducting emissions inventories for mobile sources, as well as in evaluating the impacts of emission reduction interventions that are related to vehicle and fuel technologies and operations.</p>																																														
Unit of measurement	<p>Vehicle emission factors are provided in terms of the amount or weight of pollutant emitted per vehicle activity (<u>gramme/vehicle-kilometre</u>) per vehicle type.</p>																																														

Figure 23: Example NOx emission factors (gramme/VKM) (Source: Clean Air Asia, 2012)

Methodology	<p>Emission factors are assessed primarily through laboratory or on-road tests that use emission analysers. Emission factor models enable the adjustment of base vehicle emission factors to reflect the impact of local conditions (e.g. fuel quality, operating conditions, inspection and maintenance and temperature), as well as drive cycles. These models can also be used for generating emission factors that approximate real-world conditions, albeit limited by the available information and the limitations of such models.</p> <p>A practical approach is to adopt locally calibrated base emission factors for each vehicle type-fuel type-emission standard vehicle bins, and use estimated proportions for the local vehicle fleet to arrive at weighted emission factors for each vehicle type. Updates can be based on changes in the composition of the fleet without the need to update the base emission factors.</p>
Potential data sources	<p>Studies that include NO_x emission factors for road vehicles have been conducted in some of the countries in ASEAN, although to a very limited extent. These are primarily conducted by expert institutions and laboratories, as well as academic institutions. Locally adjusted vehicle emission rates are also available from the ministries of environment for some ASEAN Member States. Emission factor databases from international sources are also available. Other international databases include the following: EMEP/EEA air pollutant emission inventory guidebook - 2016; Air Pollutant Emission Factor Library; international vehicle emissions model (IVE) ; and the TEEMP models.</p>
Remarks	<p>In many cases, vehicle emission inventories and related initiatives in the region use adjusted or even non-adjusted emission factors from other countries. The use of these must recognise that they need to be adjusted to local conditions, and that even the adjusted values may not necessarily properly approximate real-life conditions. For further guidance on relevant indicators (PM and NO_x), please go to Factsheet number 26.</p>
Related indicators	26. Road transport NO _x emissions

21. Total GHG emissions by transport mode

Section	Description
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Description This refers to the total greenhouse gas (GHG) emissions emitted by the transportation sector.

Illustrative example

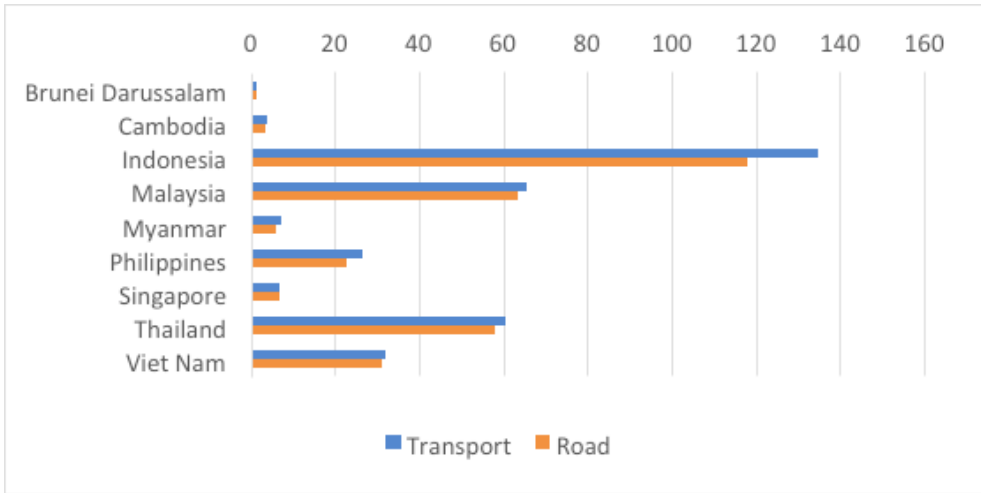


Figure 24: Transport (total & road) million tons CO₂e emissions for selected ASEAN countries (Source: IEA, 2017)

Objective and relevance This indicator keeps track of the contribution of the transportation sector in terms of GHGs. Official estimates normally include the Kyoto Protocol gases that are relevant to the transportation sector: carbon dioxide (CO₂); methane (CH₄); and nitrous oxide (N₂O). Among these GHGs, CO₂ is the primary pollutant of concern for the transport sector, as it is a direct result of the complete combustion of conventional transport fuels. Other indirect GHGs and precursor substances such as carbon monoxide, non-methane volatile organic compounds, sulphur dioxide, PM and NO_x are also calculated by some countries.

Unit of measurement Transport GHG emissions are normally reported in terms of million tonnes of CO₂-equivalent (MtCO₂e).²⁵ These Guidelines suggest that separate values for road and rail transport be provided or calculated.

Methodology

GHG emissions from the transport sector are normally calculated as part of the national GHG inventory development process. Such inventories are maintained by relevant national institutions that have been assigned to keep track of the emissions of the country. The results are reported back to the UNFCCC either through the official National Communications (NCs) or the Biennial Update Reports (BURs).

The 2006 Guidelines for National Greenhouse Gas Inventories issued by the IPCC proposes a tiered approach in calculating GHG emissions (IPCC, 2006). Countries are tasked to use an approach that is appropriate in their own context, considering the availability of data and other relevant resources. The 2006 version of the IPCC guidelines suggests that transport GHG emissions be calculated based primarily on either the fuel consumed (Tier 1 approach), or the distance travelled by the vehicles (Tier 2 and 3 approaches).

The Tier 1 approach is a calculation approach based on the consumption statistics as contained in the energy balance sheets of the countries multiplied by fuel consumption-based emission factors. This approach is also commonly referred to as a top-down approach. Default emission factors are utilised in this approach. The basic equation is given below.

$$TGHG_z = \sum (EC_a * EF_{a,x} * GWP_e)$$

Where:

$TGHG_z$ = transport GHG emissions (tCO₂e) for mode z

EC_a = transport energy consumption of fuel a consumed (TJ)

$EF_{a,x}$ = emission factor (kg/TJ) for the greenhouse gas x for fuel a; for CO₂, this is based on the fuel Carbon content of the fuel.

GWP_e = global warming potential (in terms of CO₂ equivalent for greenhouse gas e

a = fossil fuels

e = CO₂, CH₄, N₂O

z = transport modes (e.g. road, rail)

* = multiplication

It must be noted that bottom-up approaches in calculating transport GHG emissions, particularly for road transport, often refer to calculations involving estimated vehicle kilometre (VKT) data as seen in the equation below. However, in the IPCC 2006 guidelines, this approach is only recommended for calculating CH₄ and N₂O emissions. For the purposes of generating the inventory figures for the UNFCCC, the use of fuel consumption figures, combined with emission factors that are based on the carbon content (Tier 1 = default values; Tier 2 = country-specific carbon content values, if available) is enough. There is no Tier 3 (for CO₂) as it is not possible to produce significantly better results for CO₂ than by using the existing Tier 2 (IPCC, 2006). This is because CO₂ is a direct product of complete combustion, and what matters most is how much fuel is consumed, rather than how the fuel is consumed. (The latter is more relevant for CH₄ and N₂O). Although a CO₂ emissions approach based on vehicle activity (VKM) is not necessary for official reporting to the UNFCCC, it is very important in assessing the real-world impacts of interventions.

For CH₄ and N₂O, a Tier 2 emissions approach based on IPCC uses fuel consumption statistics, but these need to be disaggregated into fuel consumed by different vehicle type and emission-control technology combinations (e.g. car – Pre-Euro; car – Euro 1; and so on). A Tier 3 approach is similar in its disaggregation but uses country-specific VKT-based estimates (by vehicle emission-control technology combinations), and country-specific emission factors. The equation below is adopted from the IPCC guidelines (2006) and depicts the calculation of Tier 3 emissions calculation (road vehicle activity-based approach):

$$GHG_{RT_Tier3} = \sum \left((VKM_{a,b,c,i} * EF_{a,b,c,i}) + (Cold_{a,b,c,i} * GWP) \right)$$

Where:

- GHG_{RTTier3} = road transport emissions of CH₄ or N₂O (kg)
- EF_{a,b,c,d} = CH or N₂O emission factor (kg/km)
- VKM_{b,c,d} = distance travelled during the operation phase of vehicles
- Cold_{a,b,c,d} = cold start emissions (vehicle warm-up phase) (kg)
- a = fuel type
- b = emission control technology
- c = operating conditions
- i = vehicle type
- GWP = Global warming potential (in terms of CO₂ equivalents) for CH₄ or N₂O
- * = multiplication

The 2006 IPCC guidelines also provide a similar Tier 3 equation for calculating GHG emissions from rail locomotives.²⁶

Potential data sources

Officially submitted estimates by parties to the UNFCCC can be accessed through the UNFCCC website.²⁷ The International Energy Agency (IEA) also maintains a database of transportation CO₂ emissions estimates based on the energy balance sheets (IEA, 2017).²⁸ The Emissions Database for Global Atmospheric Research or EDGAR also provides model-estimated (road transport), and officially reported figures for transport CO₂ and GHGs (including geospatial data).²⁹

In terms of the potential data sources within countries, overall energy balance sheets, which would contain sector-specific fuel consumption estimates (used as input), are normally maintained by the energy ministries. Local Carbon content figures, if available, would also normally be with the ministry/ices of energy, environment, or science and technology. Vehicle activity-based emission factors, are normally not available, but for some countries, these can be with the same ministries as above, or are generated by studies conducted in universities.

Remarks	<p>In general, this indicator is a key indicator for monitoring the overall performance of the sector in terms of GHG emissions. However, it must be combined with other indicators, as it does not tell the whole story (i.e. overall transport GHG emissions may be increasing, while emissions intensities may be decreasing immensely).</p> <p>There are intricacies that must be noted when interpreting GHG emissions from transportation. Fuel consumption-based transport GHG estimates (country-level) are pretty straight forward, as it attributes emissions to fuel that is consumed (as proxied by fuel sales statistics) to the entity where the point of sale was made. In terms of vehicle activity-based estimates, one might think if the VKM numbers reflect vehicle activity that occurred inside the boundaries of say, a country, or do the VKM numbers reflect the activity of vehicles that are registered in a country, or both. The IPCC Guideline (2006) states that ‘emissions from road vehicles should be attributed to the country where the fuel is sold, but VKM-based estimates may not necessarily reflect this. For example, let’s consider two countries connected by land, a vehicle registered in country B was filled in a fuel station in country A. The vehicle goes back to country B and consumes most of the fuel there. Country B estimates its GHG emissions using a VKM-based approach. If it takes the VKM data from the vehicle, it would not necessarily consider the fact that the fuel was sold in country A. This example stresses the importance of doing both approaches, and cross-validating between the results to avoid either double-counting, or under estimating.</p> <p>One must also be mindful of the scope of the methodology that was used in estimating such an indicator. Tank-to-wheel emissions refer to the emissions produced from the operation of the vehicle, while wheel-to-wheel emissions take account of the emissions from the operation of the vehicles, as well as those associated with the production of energy that propels the vehicles. For GHG accounting purposes, the more important thing is to be able to account all such emissions, whether these be allocated to the final consuming sector (e.g. transport), or to the energy transformation industries. In terms of developing GHG mitigation strategies for transport, it would be ideal to use a well-to-wheel approach so that leakages (unintended increases in total GHGs) are avoided.</p> <p>Most of the official country-level estimates are based on fuel sales data. One must be mindful that transportation fuel can be used in other sectors and may not necessarily be reported appropriately. Diesel, for example, is being bought for operating non-road equipment in agriculture, construction, and industries. Also, fuel sales statistics will not include data on potential leakages, such as those due to smuggling. A vehicle activity-based approach, on the other hand, is quite complex, and accurate estimates would be more feasible if monitoring of key parameters (i.e. vehicle population disaggregation into different types, sub-types, fuel type, emission control technology, VKM) are conducted in a consistent and regular manner.</p>
Related indicators	<ul style="list-style-type: none"> 17. Total Energy Consumption by Transport Mode 22. Transport GHG Emissions per Capita by Transport Mode 23. Passenger transport GHG per PKM by Transport Mode 24. Freight Transport GHG per TKM by Transport Mode

22. Transport GHG emissions per capita by transport mode

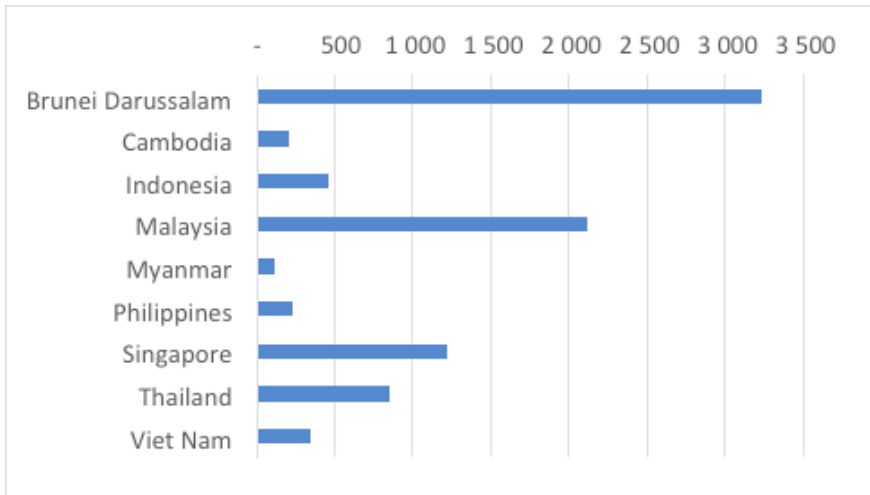
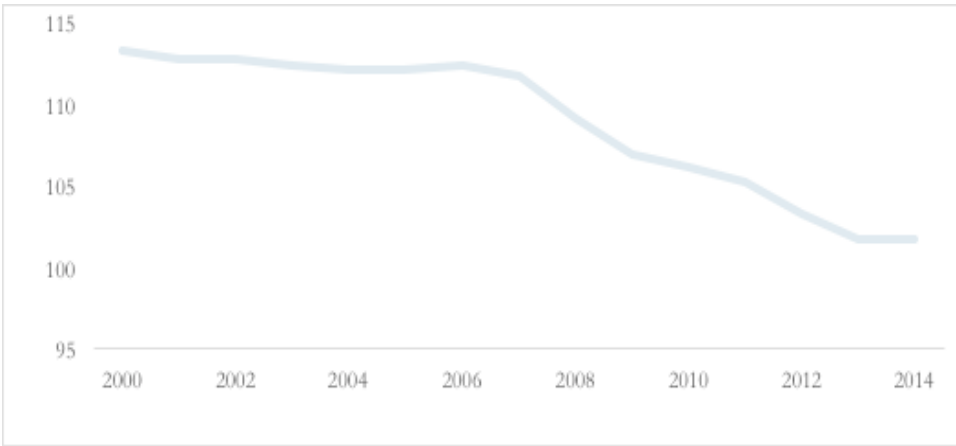
Section	Description																				
Description	<p>This indicator refers to the average per-capita greenhouse gas (GHG) emissions from transportation.</p> <p>The range of values for this indicator is quite wide based on available estimates. The IEA estimates for per capita road transport CO₂ emissions in 2015 shows that the global values range from 56 kg CO₂ to 12.6 tonnes CO₂ per capita. In ASEAN, this is between 165 kgCO₂ per capita to 3.2 tonnes per capita (IEA, 2017).</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="512 817 1385 1310"> <caption>Data for Figure 25: Transport kgCO₂ per Capita Selected ASEAN Countries</caption> <thead> <tr> <th>Country</th> <th>Transport kgCO₂ per Capita (Estimated)</th> </tr> </thead> <tbody> <tr> <td>Brunei Darussalam</td> <td>3200</td> </tr> <tr> <td>Cambodia</td> <td>200</td> </tr> <tr> <td>Indonesia</td> <td>400</td> </tr> <tr> <td>Malaysia</td> <td>2100</td> </tr> <tr> <td>Myanmar</td> <td>100</td> </tr> <tr> <td>Philippines</td> <td>150</td> </tr> <tr> <td>Singapore</td> <td>1200</td> </tr> <tr> <td>Thailand</td> <td>800</td> </tr> <tr> <td>Viet Nam</td> <td>300</td> </tr> </tbody> </table>	Country	Transport kgCO ₂ per Capita (Estimated)	Brunei Darussalam	3200	Cambodia	200	Indonesia	400	Malaysia	2100	Myanmar	100	Philippines	150	Singapore	1200	Thailand	800	Viet Nam	300
Country	Transport kgCO ₂ per Capita (Estimated)																				
Brunei Darussalam	3200																				
Cambodia	200																				
Indonesia	400																				
Malaysia	2100																				
Myanmar	100																				
Philippines	150																				
Singapore	1200																				
Thailand	800																				
Viet Nam	300																				
Objective and relevance	<p>This indicator is a measure of transport emissions performance. It approximates the average GHG emissions that is being emitted by each individual belonging to an entity (country) at a given time. Monitoring transport GHG emissions per capita can be an effective way to keep track of the emissions performance of entities, particularly countries, and is a relatively easy-to-understand metric.</p>																				
Unit of measurement	<p>Transport GHG emissions per capita is normally reported in terms of CO₂-equivalent unit of mass per person (<u>kgCO₂e/capita</u>).³⁰ These Guidelines suggests that values be inputted/calculated for <u>road and rail</u>, separately.</p>																				

Figure 25: Transport kgCO₂ per Capita Selected ASEAN Countries (Source: IEA, 2017)

Methodology	<p>This indicator is derived by dividing the total passenger transport GHGs by the population.</p> $GHGCAP_z = \frac{GHG_z}{Pop}$ <p>Where: GHGCAP_z = per-capita transport emissions for mode z GHG_z = emissions for the road transport sector (Factsheet 21) Pop = total population (Factsheet 1) z = transport modes (i.e. road, rail)</p> <p>Please refer to the Factsheet 21 on Total Transport GHG Emissions for an explanation of the methodology for deriving the total emissions from transport.</p>
Potential data sources	<p>The International Energy Agency publishes a report titled CO₂ Emissions from Fuel Combustion (and accompanying Excel file) annually. The said publication contains estimated transport CO₂ emissions per capita (including specific values for road transport) (IEA, 2017). Transport GHG emissions estimates can also be divided by the population, which can be obtained and collated a national level through various sources such as the data.worldbank.org and data.un.org.</p> <p>Country-specific relevant data can be obtained from the ministries of environment, energy, and statistics. Official transport GHG estimates can be divided by the official estimates of population size to obtain the indicator.</p>
Remarks	<p>Although this indicator is quite useful in communicating the general trends in terms of the emissions performance of an entity, it should be used in conjunction with other indicators. The decrease in transport emissions per capita may not necessarily equate to improved environmental performance, it can also just mean that the population is growing significantly faster than transport emissions. The indicator also does not provide a sense of the aggregate emissions from transportation.</p>
Related indicators	<ol style="list-style-type: none"> 1. Total population 21. Total GHG emissions by transport mode

23. Passenger transport GHG per PKM by transport mode

Section	Description																		
<p>Description</p> <p>This indicator refers to the greenhouse gas (GHG) emitted per passenger-kilometre (PKM).³¹</p> <p>To provide an idea of the range of values expected for this indicator, a figure from the European Environment Agency is provided below for road transport. This depicts the average values for the European Union as a whole. It is important to note that values across the globe will vary and may not necessarily coincide closely with the values provided below.³²</p> <p><i>Illustrative example</i></p>  <table border="1" data-bbox="477 795 1437 1238"> <caption>Data for Figure 26: Gramme CO2/PKM- road transport in EU</caption> <thead> <tr> <th>Year</th> <th>Gramme CO₂/PKM</th> </tr> </thead> <tbody> <tr> <td>2000</td> <td>113</td> </tr> <tr> <td>2002</td> <td>112.5</td> </tr> <tr> <td>2004</td> <td>112</td> </tr> <tr> <td>2006</td> <td>112.5</td> </tr> <tr> <td>2008</td> <td>107</td> </tr> <tr> <td>2010</td> <td>105.5</td> </tr> <tr> <td>2012</td> <td>103</td> </tr> <tr> <td>2014</td> <td>102</td> </tr> </tbody> </table>	Year	Gramme CO ₂ /PKM	2000	113	2002	112.5	2004	112	2006	112.5	2008	107	2010	105.5	2012	103	2014	102	<p>Figure 26: Gramme CO₂/PKM- road transport in EU (Source: EEA, 2017)</p>
Year	Gramme CO ₂ /PKM																		
2000	113																		
2002	112.5																		
2004	112																		
2006	112.5																		
2008	107																		
2010	105.5																		
2012	103																		
2014	102																		
<p>Objective and relevance</p>	<p>This indicator is a measure of emissions intensity of passenger transport per PKM across different vehicles, modes and systems. It is a popular measure as it directly links total emissions with total activity performed.</p>																		
<p>Unit of measurement</p>	<p>Transport GHG emissions per PKM is normally reported in terms of CO₂-equivalent unit per PKM (e.g. <u>grammeCO₂e/PKM</u>).³³ These Guidelines suggests that values be inputted/calculated for <u>road and rail</u>, separately.</p>																		

Methodology	<p>This indicator is determined by dividing the total transport GHGs by the estimated PKM performed.</p> <p>If the official transport GHG figures are calculated using the overall energy balance sheets in a top-down manner, it is not possible to directly get the emissions attributed to passenger transport. For example, diesel consumption from road transport can be from both passenger and freight vehicles. A bottom-up calculation approach may be necessary. Please refer to the Factsheet 21 (transport GHG emissions) and Factsheet 5 (PKM) for further guidance on the input parameters for this indicator.</p> $GHGPKM_z = \sum \left(\frac{GHG_x}{PKM_x} \right)$ <p>Where:</p> <ul style="list-style-type: none"> GHGPKM_z = passenger transport GHGs per PKM (kgCO₂e/PKM) for mode z GHG_x = GHGs from passenger vehicle belonging to mode z (kgCO₂e) PKM_x = total passenger kilometres performed by passenger vehicle x belonging to mode z (PKM) z = transport modes (i.e. road, rail)
Potential data sources	<p>This indicator is dependent on total passenger transport GHG emissions and total PKM, regardless of whether one is looking at specific vehicles, modes, or systems. Country-specific relevant transport GHG emissions estimates can normally be obtained from the ministries of environment, energy, and statistics. However, robust PKM estimates are normally not available from these sources. Model-estimated PKM values may be available through studies conducted or commissioned by ministries of transport or public works. PKM data may be also be available at universities, or collected by public transport operators. Surveys conducted by statistics ministries and others may also provide estimates of passenger transport activity, for example, household surveys containing data on the number of trips made by household members, and their usual destinations. However, generalising from such samples would be difficult.</p>
Remarks	<p>At the country level, the estimates of passenger transport GHG emissions are less uncertain, as these can be checked against the total transport GHG emissions, which are calculated based on fuel sales statistics. The later, in most cases, are regularly monitored, and can be cross-checked with other data sources such as tax data. However, the total PKM performed by the elements in the system is not often monitored and is difficult to estimate. PKM data can be easier to monitor for public transport modes if appropriate monitoring and reporting systems are put in place that compel operators to collect and report the data. Monitoring this for private passenger vehicles is more difficult. Countries can look into instituting regular odometer readings as part of mandatory vehicle inspections. This would decrease the uncertainty of estimated vehicle kilometres (PKM = VKM * average number of passengers).³⁴ Average occupancies (passengers) can then be estimated using vehicle surveys. Also, as explained beforehand, a bottom-up approach may be necessary to get a proper approximation of the disaggregation between passenger and freight CO₂ emissions, which can then be counter-checked with top-down estimates.</p>
Related indicators	<ul style="list-style-type: none"> 5. Total PKM by transport mode 21. Total GHG emissions by transport mode

24. Freight transport GHG per TKM by transport mode

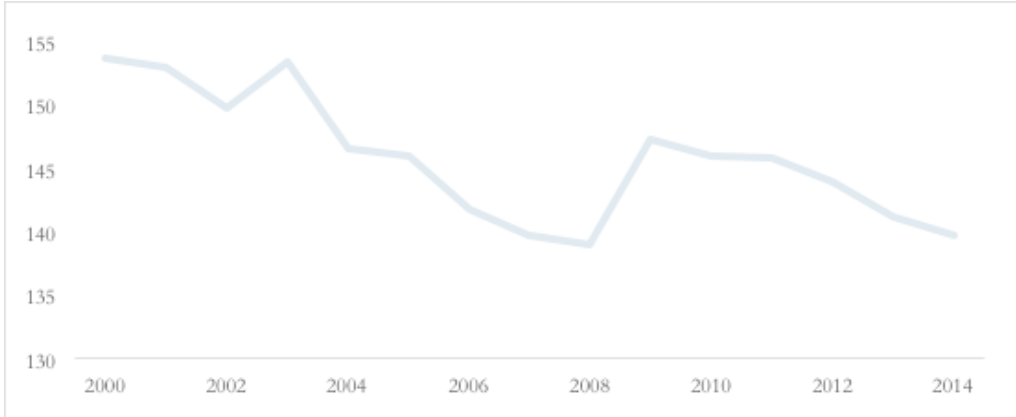
Section	Description
<p>Description</p>	<p>This indicator refers to the greenhouse gas (GHG) emitted per tonne-kilometre (TKM) of freight transport.³⁵</p> <p>The range of values for this indicator varies depending on different parameters. If one is looking at specific vehicles, the gCO₂e/TKM would depend primarily on its capacity, average loading, fuel type and energy efficiency. If a specific freight mode is being looked at, the average gCO₂e/TKM would depend on the factors listed above, for all the vehicles that are included in the mode. Other factors such as efficiency in operations can also be important. If the overall gCO₂e/TKM average for a system is being looked at, the aforementioned factors would be important, as well as other factors such as the mode choice of freight customers.</p> <p><i>Illustrative example</i></p> 
<p>Objective and relevance</p>	<p>This indicator is a measure of emissions intensity of freight transport, by different vehicle types, modes, and systems. It pertains to the amount of GHG that is emitted per unit of freight activity. It is a popular measure of the emissions efficiency of a freight transportation as it directly links total emissions with total activity.</p>
<p>Unit of measurement</p>	<p>Transport GHG emissions per TKM are normally reported in terms of CO₂-equivalent unit per TKM (grammeCO₂/TKM).³⁶ These Guidelines suggests that these values be calculated for both <u>road and rail</u>, separately.</p>

Figure 27: Gramme CO₂/TKM – road transport in EU (Source: EEA, 2017)

Methodology This indicator is calculated by dividing the total transport GHGs by the estimated TKM.

If the official transport GHG figures are calculated using the overall energy balance sheets in a top-down manner, it is not possible to directly obtain the disaggregated emissions attributed to freight transport. For example, diesel consumption by road transport can be from both passenger and freight vehicles. A bottom-up calculation approach may be necessary.

Please refer to the Factsheet 21 (transport GHG emissions) and Factsheet 7 (tonne-kilometres) for further guidance on the input parameters for this indicator.

$$GHGTKM_z = \sum \left(\frac{GHG_y}{PKM_y} \right)$$

Where:

- GHGPKM_z = freight transport GHGs per TKM (kgCO₂e/TKM) for mode z
- GHG_y = total GHGs from freight vehicle y belonging to mode z (kgCO₂e)
- PKM_z = total passenger kilometres performed by freight vehicle y belonging to mode z (PKM)
- z = transport modes (i.e. road, rail)

Potential data sources This indicator is dependent on total freight transport GHG emissions and total tonne-kilometres performed, regardless of whether one is looking at specific vehicles, modes, or systems. Country-specific relevant transport GHG emission estimates can normally be obtained from the ministries of environment, energy, and statistics. However, robust tonne-kilometre estimates are normally not available from these sources. Model-estimated TKM values may be available through studies conducted or commissioned by the ministries of transport or public works. TKM data may be also be available from universities, or collected by public transport operators. Data collection methods such as establishment surveys, freight operator surveys, vehicle observation surveys, driver surveys, roadside interview surveys, vehicle trip diaries and the use of GPS data, can be useful in generating TKM estimates (Allen et al., 2012).

Remarks	<p>Tonne-kilometre data can be easier to monitor for maritime transport and rail-based freight transport for several reasons: these sectors already employ mechanisms for recording freight volume; the distances travelled are more or less consistent; and there are existing entities that collect and organise such data. Road freight TKM is a particular challenge, especially in ASEAN, as the sector is quite fragmented, and many operators do not necessarily collect or report loading and distance data. Countries can look into instituting mandatory odometer readings as part of periodic vehicle inspections, which would decrease the uncertainty of estimated tonne-kilometres. Participation from operators, freight groups and associations may be necessary in order to properly estimate TKM values. Also, as explained above, a bottom-up approach may be necessary to get a proper approximation of the disaggregation between passenger and freight CO₂ emissions, which can then be double-checked with top-down estimates.</p> <p>This indicator, even if useful in gauging the emission intensity of freight transport, should not be interpreted in isolation. For instance, a very inefficient freight vehicle may perform exceptionally well in terms of gCO₂e/TKM, but this could just mean that it is running overloaded most of the time, which is an issue related to service quality, and more importantly, safety.</p>
Related indicators	<p>7. Total tonne-kilometres by transport mode 21. Total GHG emissions by transport mode</p>

25. Road transport particulate matter emissions

Section	Description
Description	Particulate matter (PM) is a collective term referring to solid or liquid particles in the atmosphere (Vallack & Rypdal, 2012), and is a significant pollutant generated by road vehicles.
Objective and relevance	<p>Monitoring the amount of particle emissions from transportation is particularly important from a health perspective. Particulate matter (PM) has been implicated as the air pollutant most deserving of urgent policy attention due to its impacts on human health. Addressing PM emissions from road vehicles is important in managing urban air quality due to their significant contributions to the emission loads, as well as their proximity to human populations(Gorham, 2002). The size and composition of the particles are directly related to the health impacts of PM. Fine particles (with diameters <2.5 microns or PM2.5) are considered to pose the greatest risk to human health as they can lodge deep in the lungs and interfere with respiratory functions (USEPA, 1996).</p> <p>Fuel combustion is one of the major sources of particulate matter.³⁷ In urban areas, transportation is one of the main sources of particulate pollution.</p>
Unit of measurement	The amount of particulate matter emissions is normally reported using mass units over a period of time (<u>tonnes/year</u>).
Methodology	<p>Mobile source emissions are estimated using a variety of approaches. Direct measurement can be done in vehicle laboratories with the appropriate equipment and local drive cycles, or emission-test cycles (HEI, 2010). Direct measurement is also possible off-road using portable emissions measurement devices. Localised emission factors (gramme pollutant/vehicle kilometre) from such tests can be used in developing larger-scale emission inventories. The amount of emissions is estimated in inventories using the general formula:</p> $PM = \sum VKM_{a,b,c,i} * PM EF_{a,b,c,i}$ <p>Where:</p> <ul style="list-style-type: none"> PM = particulate matter emissions for road transport (grammes) VKM_{a,b,c,i} = vehicle-kilometres driven (VKM) PM_{a,b,c,i} = particulate matter emission factors (gramme/VKM) a = fuel type b = emission control technology c = operating conditions i = vehicle type * = multiplication

The simplest method is to multiply vehicle kilometre estimates by the appropriate emission factors for each vehicle type. If local vehicle emissions models based on empirical observations are available, then a more sophisticated approach is utilised, one that captures the changes in emissions based on the changes on the characteristics of driving and environmental conditions. For macro-level estimates, changes in the amount of emissions are primarily driven by assumptions on vehicle numbers, the percentage distribution of these vehicles according to their fuel types, the VKM driven, and the distribution of vehicles based on emission standards. The latter is particularly important in macro-level estimates, as vehicle emission standards, and the use of appropriate particulate matter exhaust technologies, heavily determine particulate pollution, along with other air pollutants. Unlike CO₂ estimation, which is primarily a question of how much fuel is burnt, estimating particulate matter pollution is also concerned with how the fuel is burnt. Particulate matter from transportation is also generated through non-combustion-related processes such as tyre wear and evaporative losses (e.g. during fuel transportation and re-fuelling). Indirectly, road dust resuspension is also an issue for urban transport, although these may not necessarily be captured in national-level inventories.

Potential data sources	National air pollutant emission inventories are being conducted in several ASEAN countries, and are normally within the purview of ministries of environment.
Remarks	By themselves, aggregated estimates of particulate matter emissions will not necessary provide definitive insights on how transportation is directly impacting the health of the citizenry. There are other external factors that need to be taken into consideration, such as meteorology, other sources of pollution, and types of pollution. For example, vehicular pollution from urban driving has greater health impacts than that emitted in isolated highways. Also, national level inventories (particularly in developing countries) are often limited by data availability, as well as appropriate, localised emission factors that would adequately capture the characteristics of its fleet. Moreover, emission factor models (and accompanying vehicle activity data) that would dynamically capture the magnitude of impacts from the different driving conditions are also lacking. Such variations in vehicular activity conditions are supposedly captured in the emission factors themselves (as these are generated using drive cycles that mimic real-life conditions), but local emission factors are also not often available in many developing countries.
Related indicators	3. Total road VKM travelled 19. Particulate matter emission factors of road vehicles

26. Road transport NO_x emissions

Section	Description
Description	<p>This indicator provides information on the levels of Nitrogen oxides (NO_x) emitted by road transportation. Nitrogen oxides are formed through high temperature combustion processes and have a wide range of negative health and environment impacts. The term NO_x is a collective term that is used to refer to nitrogen monoxide (NO), nitrogen dioxide (NO₂), nitrous oxide (N₂O) and their derivatives (Boningari & Smirniotis, 2016).</p> <p>NO_x are also a contributor to the formation of secondary air pollutants such as tropospheric (ground-level) ozone which also impacts human and ecological health. It also contributes to the formation of acid rain (Boningari & Smirniotis, 2016). Transportation is a major source of anthropogenic emissions. In EU, for example, transportation accounted for more than 60% of the total anthropogenic NO_x emissions in 2001. NO_x are particularly a concern for diesel vehicles, which operate at higher temperatures compared to gasoline vehicles, which in turn favours the formation of NO_x. NO_x emission controls in vehicles include both combustion control and post-combustion removal processes, some of which have trade-offs against fuel economy. For example, recirculating exhaust gas to reduce NO_x emissions also reduces fuel economy and power due to the lowered operating temperatures. This particular challenge has resulted in car manufacturers using so-called defeat devices to circumvent regulatory standards. On-road tests reveal that cars equipped with such devices emit up to four times the applicable emission limits during on-road, real-world use (Chossiere, et al., 2017).</p>
Objective and relevance	<p>Monitoring NO_x emissions is important from both health and environment perspectives. NO_x emissions can contribute to lung damage and respiratory function impairment such as bronchitis and emphysema, as well as exacerbating heart disease. Nitrous oxide (N₂O) is also a potent greenhouse gas and has a global warming potential of 310 carbon dioxide equivalent as per the IPCC.</p>
Unit of measurement	<p>The estimated amount of NO_x emissions is normally reported using mass units over a period of time (<u>tonnes/year</u>).</p>
Methodology	<p>'Mobile sources' is another term that is used to refer to sources of emissions from the transport sector, but it must be noted that this lumps on-road and non-road sources (HEI, 2010). Mobile source emissions are estimated using a variety of approaches. Direct measurement can be done in vehicle laboratories with the appropriate equipment, and local drive cycles, or emissions test cycles. Direct measurement is also possible on-road using portable emissions measurement devices. Localised emission factors (gramme pollutant/vehicle kilometre) from such tests can be used in developing larger scale emission inventories. The amount of emissions is estimated in inventories using the formula:</p>

$$NOx = \sum VKM_{a,b,c,i} * NOx EF_{a,b,c,i}$$

Where:

NO_x = articulate matter emissions for road transport (grammes)

VKM_{a,b,c,i} = VKM driven

NOx_{a,b,c,i} = particulate matter emission factors (gramme/VKM)

a = fuel type

b = emission control technology

c = operating conditions

i = vehicle type

* = multiplication

The simplest method is to multiply VKM estimates by the appropriate emission factors for each vehicle subset. If local vehicle emissions models based on empirical observations are available, then a more sophisticated approach is utilised, one that captures the changes in emissions based on the changes in the characteristics of driving and driving conditions. For macro-level estimates, changes in the amount of emissions are primarily driven by assumptions on vehicle numbers, the percentage distribution of these vehicles according to their fuel types, the VKM driven, and the distribution of vehicles based on emission standards. This distribution is particularly important in macro-level estimates, as vehicle emission standards heavily determine NOx emission rates, along with other air pollutants. As with particulate matter, estimating NOx emission rates also depend on how fuel is burnt, and not just how much fuel is burnt.

Potential data sources	National air pollutant emission inventories are being conducted in several ASEAN countries, normally within the purview of ministries of environment.
Remarks	By themselves, aggregate estimates of NOx emissions do not necessary provide definitive insights on how transportation is directly impacting the health of the citizenry. There are other external factors that need to be taken into consideration, such as meteorology, other sources of pollution, and types of pollution. For example, vehicle pollution from urban driving results in more significant health impacts than pollution emitted in isolated highways. Also, national-level inventories, particularly in developing countries, are often limited by data availability, as well as a shortage of appropriate, localised emission factors that would adequately capture the characteristics of its fleet. Moreover, there is also a lack of emission factor models and accompanying vehicle activity data that would dynamically capture the magnitude of impacts from the different driving conditions. Such variations in vehicular activity conditions are supposedly captured in the emission factors themselves, as these are generated using drive cycles that mimic real-life conditions, but local emission factors are also often unavailable in many developing countries.
Related indicators	3. Total road VKM travelled 20. NOx emission factors of road vehicles

27. Gross domestic product

Section	Description
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Description Gross domestic product is an economic indicator that can be defined as the value of the ‘final uses of goods and services measured in purchasers’ prices, less the value of imports of goods and services, or the sum of primary incomes distributed by resident producer units’ (UN Statistics Division, 2017). It is primarily used as an indicator of the overall size of the economy.³⁸ Simply stated, GDP is the sum of the value added generated by producers residing in the economic territory of a country during the accounting period (OECD, 2006).

Illustrative example

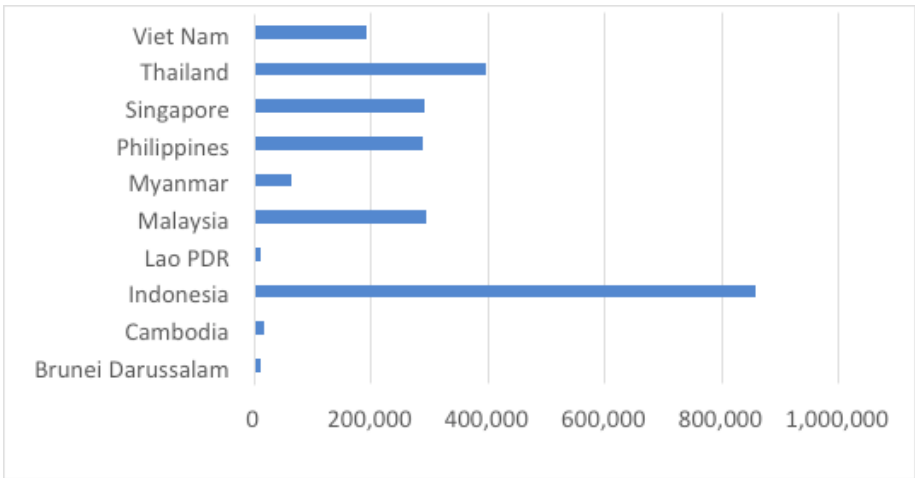


Figure 28: 2015 GDP current million USD (Source: ASEANStat)

Objective and relevance	GDP is a primary indicator normally used to evaluate the state and movement of the overall size of a country’s economy. For the purposes of these Guidelines, GDP is primarily used as a normalisation factor for several of the other indicators. Using GDP as such provides insights on evaluating intensities of relevant parameters (e.g. emissions, energy or vehicle activity) in relation to generating relevant economic outputs.
Unit of measurement	For the purposes of these Guidelines, it is recommended that the values collated and reported by ASEANStats be used in order to maintain consistency and ease of access to data. This uses current nominal values in USD to report GDP in ASEAN.
Methodology	Data can be taken from official sources, or from the values collated by the ASEANStats.
Potential data sources	Official GDP estimates are normally available from the ministries of economic development, or the statistical ministries. The ASEANStats website also has GDP figures for selected years in the data tables in its website (https://data.aseanstats.org/).
Remarks	Real GDP values may also be used, as long as the type of GDP values used is consistent across time and countries.
Related indicators	6. PKM per GDP by transport mode 8. Tonne-kilometres per GDP by transport mode 18. Energy consumption per GDP by transport mode

28. Freight rates

Section	Description
Description	Freight rates provide information on the amount of money that is typically being paid by substantial, regular users of freight services on a per tonne-kilometre basis (BITRE, 2013). The figure below illustrates the potential ranges for such freight rates based on the calculated freight rates in Australia from 1996-2003 (BITRE, 2013).

Illustrative example

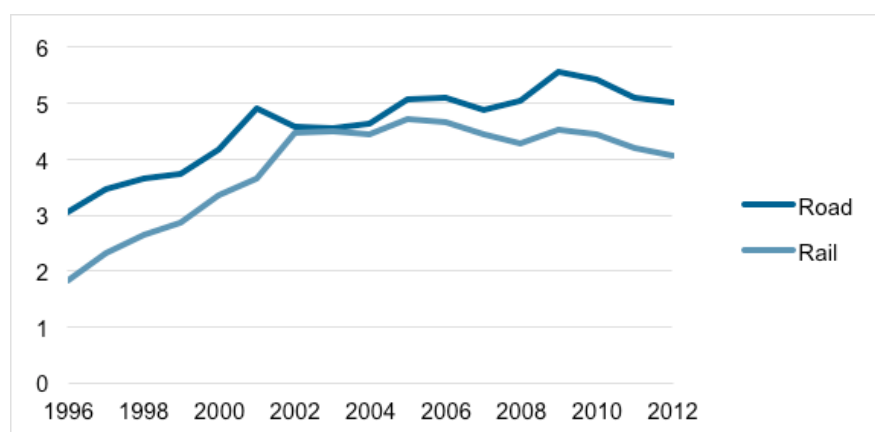


Figure 29: Freight rates in Australia (cents/TKM) (Source: BITRE, 2013)

Objective and relevance	This indicator aims to monitor the movement of the costs of moving a tonne of goods over a kilometre. It provides a better understanding of the international transport sector in itself, as well as its evolution and its characteristics. Transport costs data enable a better understanding of the relation with the international geography of trade volumes and prices (Gaulier, 2008).
Unit of measurement	<u>Unit price (USD cents) per TKM</u>
Methodology	Ideally, freight rates for all movements by mode are required to calculate such an indicator (BITRE, 2013). The type of cargo, mode used, weight, distance transported and type of service (e.g. refrigerated freight) are some of the key factors considered in categorising such rates.
Potential data sources	The data sources usually include the transport industry service providers. Data are also collated from projects where clients are assisted in looking for freight services, as well as data from projects that assist freight service providers to tender quotes (BITRE, 2013). In ASEAN, initiatives by international organisations such as the Asian Development Bank (through the Greater Mekong Sub-Region Environment Operations Centre), and GIZ have engaged in projects that aim to collect information on freight rates. Conversations with industry associations would also yield reasonable estimates or ranges for such an indicator.

Remarks	The calculation of average freight rates tends to be complex as such an indicator reflects various components such as fuel consumption, impacts of geography (e.g. on fuel consumption), empty backhauls, taxes and tolls, and subsidies (Rodrigue, Comtois, Slack. 2006). However, if existing information is collected or included in commodity flow surveys, its reporting would be beneficial in tracking the general trends in transportation-related costs.
Related indicators	

29. Fossil fuel subsidy for transport

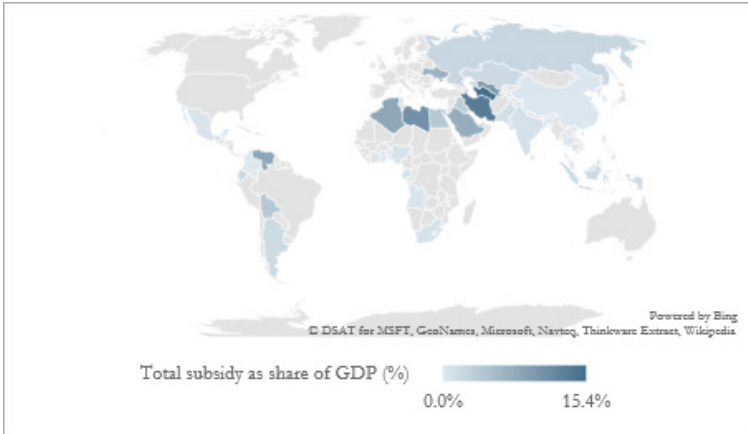
Section	Description
Description	<p>This indicator depicts the levels of subsidies towards fossil fuels, depicted as a percentage the GDP of a country.</p> <p>The map below depicts the values that have been estimated by the IEA (2017b).</p> <p><i>Illustrative example</i></p>  <p>The map shows the following approximate subsidy levels by region:</p> <ul style="list-style-type: none"> High Subsidy (Dark Blue, ~15.4%): Countries in Africa (e.g., Nigeria, Egypt, Algeria), the Middle East (e.g., Saudi Arabia, Iraq, Kuwait), and parts of Asia (e.g., India, China). Medium Subsidy (Light Blue, ~5-10%): Countries in South America (e.g., Brazil, Venezuela), and parts of Europe and Asia. Low Subsidy (Very Light Blue, ~0.0%): Most countries in North America, Europe, and Australia.
Objective and relevance	<p>Substantial reductions in fossil fuel subsidies are being regarded as an effective mechanism to curb the consumption of such fuels, and thus contribute towards the reduction of greenhouse gas pollutants. The UNFCCC, for example, has listed fossil-fuel subsidy reform as a thematic intervention area that provides significant mitigation benefits, and other co-benefits (UNFCCC, 2013). The reduction of subsidies for fossil fuels can also improve the fiscal balances of countries, minimise market distortions, and increase private-sector investments (GSI & IISD, 2013).</p>
Unit of measurement	<p>This indicator is reported in terms of fossil fuel subsidies as a <u>percentage of GDP</u>.</p>
Methodology	<p>There are several approaches that have been adopted by global institutions in calculating energy subsidies, with varying definitions. Existing definitions may include government spending on infrastructure that enables the fossil fuel industries, consumer subsidies, or the costs of externalities that are associated with the consumption of the fuels that are priced lower than they ought to be priced.</p> <p>Where:</p> <p>FFSGDP% = fossil fuel subsidy as a percentage of GDP FFS = fossil fuel subsidy (current USD) GDP = gross domestic product (current USD)</p>

Figure 30: Total fossil fuel subsidy as % of GDP (Source: IEA, 2017b)

Potential data sources	Country level estimates are provided by global organisations such as the IEA, the International Monetary Fund (IMF), OECD, and the UK development think tank Overseas Development Institute. The most comprehensive is the data set of the IMF. The IEA covers 40 developing countries, while the OECD data covers the BRICS countries (Brazil, Russia, India, China and South Africa) as well as Indonesia.
Remarks	While the estimates provided by the organisations mentioned above may differ in terms of their definitions and methodologies, it is worth while looking at these numbers, particularly in terms of tracking countries' progress in terms of fossil fuel subsidy reforms across time.
Related indicators	

30. Transport infrastructure investments

Section	Description
Description	This indicator refers to the investments on new transportation infrastructure construction or improvement, and considers all sources of funding, as well as the different transport modes. If data specific to land transport infrastructure investments are available, these should be indicated.
Objective and relevance	Investments made in transportation infrastructure is a key element that drives the performance of the transportation systems. ³⁹ The provision of infrastructure that enables efficient transport also provides benefits such as increased market accessibility, increased productivity, employment generation, and creating better community linkages. ⁴⁰
Unit of measurement	This is provided in terms of <u>current US dollars</u> .
Methodology	Data from official counts are suggested to be used. If data specific to land transport infrastructure investments are available, these should be indicated.
Potential data sources	Data on transportation investments are normally available through the relevant national government agencies such as the ministries of economic planning or finance.
Remarks	The movements of investments across time is also useful in terms of understanding further relationships between transportation infrastructure investments and the state of transport.
Related indicators	

31. Climate finance for transport

Section	Description
Description	<p>This indicator refers to the share of financing from climate-related mechanisms in the total investments in transportation.</p> <p>The UNFCCC refers to climate finance as ‘local, national or transnational financing’ which may be taken from ‘public, private and alternative sources.’ Such financing is critical in both climate change mitigation and adaptation (UNFCCC, n.d.). The importance of the provision of financial resources from developed countries to developing countries for both climate change mitigation and adaptation is emphasised in the Paris Agreement (UNFCCC COP, 2015). Article 9 also stipulates that scaling up financial resources for climate should be driven by an aim to achieve a balance between adaptation and mitigation, and should take into account country-driven strategies, priorities, and needs (UNFCCC COP, 2015). The 21st Conference of Parties (COP) to the UNFCCC also put forth a decision that it shall set a ‘new collective quantified goal from a floor of 100 billion USD per year, considering the needs and priorities of developing countries’ (UNFCCC, n.d.).</p>
Objective and relevance	<p>The indicator provides information on the adequacy and effectiveness of climate mechanisms in supporting transportation-related climate change mitigation and adaptation measures. It can also guide countries with climate commitments in future programming of investments in such projects, or relevant mechanisms.</p>
Unit of measurement	<p>This is provided in terms of <u>current U.S. dollars (USD)</u>.</p>
Methodology	<p>The data available through the relevant government agencies are based on climate budgeting systems, wherein climate-related monies are tagged, analysed, and reported. If data specific to land transport infrastructure investments are available, these should be indicated.</p>
Potential data sources	<p>Data on climate finance are normally available from the ministries responsible for economic planning, either those of finance, or of the environment. The available databases for the different climate mechanisms are also useful in generating more detailed insights. The UNFCCC, for example, has a Climate Finance Data Portal which contains information on climate finance mechanisms, and relevant reports.⁴¹ The Partnership on Sustainable Low Carbon Transport (SLoCaT) also provides transport-specific climate finance information in its website.⁴² The biennial update reports (BURs) to the UNFCCC that are submitted by the developing parties (or countries) should also contain information on the needs for finance.⁴³</p> <p>Data specific to international climate mechanisms are also available. The chart below, for example, shows the collated data for the different transport projects that have funding components that have been contributed by the international mechanisms.</p>

Remarks	Transparency in relation to climate funds is important not only for attracting additional external funds, but also for prioritising government spending. It is also worthwhile taking note of the investments from other sources (e.g. state entities, public-private partnerships or the private sector). Looking specifically at the contributions from international climate-related funding mechanisms is also important, in order to properly assess the effectiveness of such mechanisms in supporting climate mitigation and adaptation.
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Related indicators

32. Road fatalities per million vehicles

Section	Description
Description	This indicator is a measure of road safety and normalises road-related fatalities using vehicle population numbers.

Illustrative example

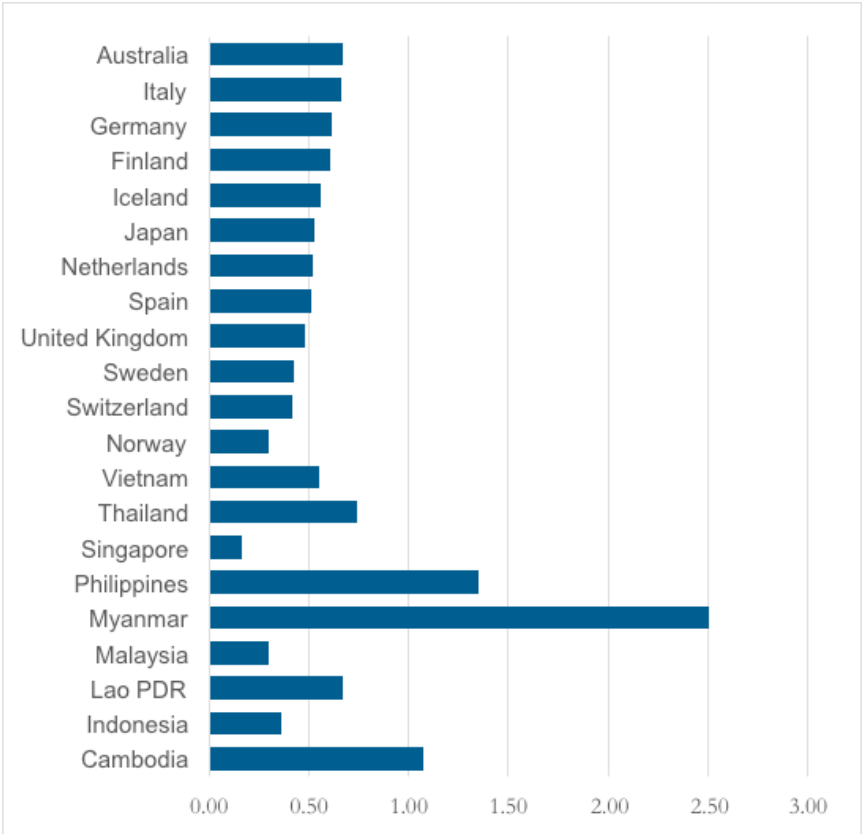


Figure 31: Road fatalities per million vehicles for selected countries (Source: UNECE)

Objective and relevance	Road fatalities have been recognised as a global concern. The World Health Organization (WHO) estimates that road traffic crashes are the main cause of deaths among people aged 15-29 years old (WHO, 2015). In fact, the Sustainable Development Goals include a road traffic deaths reduction target of 50% by 2020. Monitoring fatalities in relation to vehicular activity supplements how governments can analyse progress in terms of road safety.
Unit of measurement	This indicator is reported in terms of <u>deaths/million vehicles</u> .

Methodology The number of fatalities is divided by the estimated number of vehicles to calculate this indicator. The World Health Organization (WHO) defines road fatalities as deaths resulting from road traffic crashes involving at least one moving vehicle.⁴⁴ A more technical definition of road traffic crashes is provided by the ITF as the number of persons who died due to road accidents, immediately or within 30 days of the accident (Eurostat, 2009). Road safety advocates are promoting the use of the term ‘crashes’ instead of ‘accidents,’ as the previous encompasses a wider range of potential causes (e.g. intoxication, speeding, being distracted, careless driving, etc...) of such occurrences (NCBI, 2002).

$$RFMV = \sum \left(\frac{\text{Road fatalities}}{\text{Total vehicles}/10^6} \right)$$

RFMV = road fatalities per million vehicles

Road fatalities = road crashes-related fatalities

Total vehicles = total number of vehicles

Fatalities per unit of vehicular activity (e.g. million VKM) can also be calculated, provided that the VKM estimates are robust, and estimated in a consistent manner.

Potential data sources National statistics on road fatalities are normally available, and aggregates data from other local sources such as the ministries of health, or the police. The WHO also has a repository of road fatality data at the country level, which is also based on data from the national governments.⁴⁵

Remarks The indicator should be seen within the context of the total fatalities, as rapid increases in vehicle registrations may result in seemingly better road safety conditions. Also, the proportions of fatalities per type of road user may also provide additional insights (e.g. pedestrians, cyclists, vehicle users) into efforts that should go into alleviating avoidable road deaths.

Related indicators 9. Total Road Vehicles

33. Road non-fatal injuries per 10,000 vehicles

Section	Description
Description	This indicator is a measure of road safety and relates non-fatal due to road crashes with the vehicle population.

Illustrative example

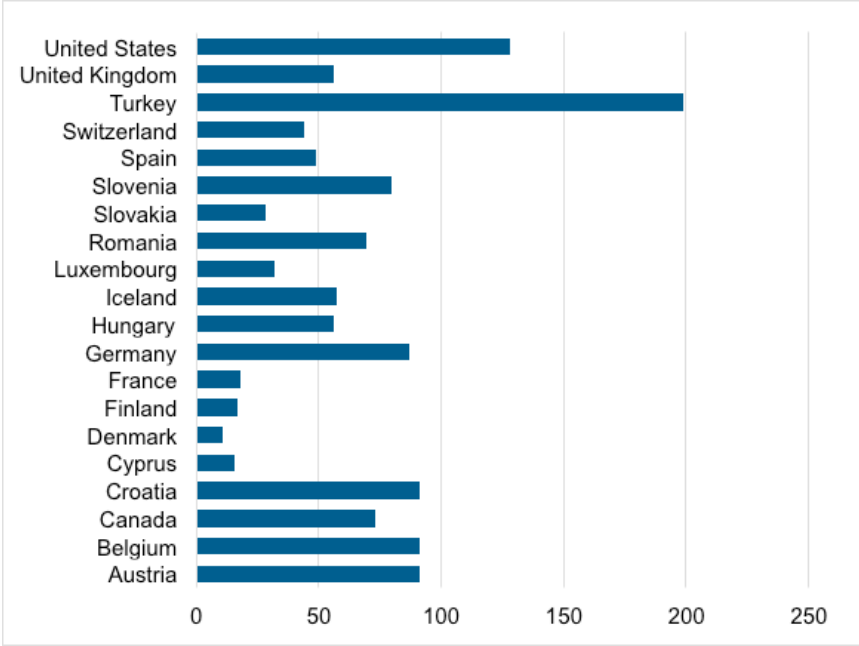


Figure 32: Road non-fatal injuries per 10,000 vehicles (Source: UNECE)

Objective and relevance	The World Health Organization (WHO) estimates that for every road fatality, there are at least twenty other persons that injured in due to road crashes. Such injuries from road crashes may result in significant impacts on the victims' quality of life, as well as economic burdens to the state, and the victims themselves (WHO, 2015). Monitoring such instances of injuries supplements how governments can analyse progress in terms of road safety. Also, a significant number of countries worldwide have issued targets on the reduction of non-fatal injuries due to road crashes.
Unit of measurement	This indicator is reported in terms of <u>non-fatal injuries/10,000 vehicles</u> .

Methodology The number of non-fatal injuries is divided by the estimated number of vehicles to calculate this indicator. These injuries can be defined as those non-fatal injuries resulting from road traffic crashes involving at least one moving vehicle (WHO).⁴⁶ The ITF provides a more restrictive definition of a road accident as one that causes injuries requiring medical treatment. Road safety advocates are promoting the use of the term ‘crashes’ instead of ‘accidents,’ as the former encompasses a wider range of potential causes, such as intoxication, speeding, distraction, or careless driving (NCBI, 2002).

$$RNFITV = \sum \left(\frac{RNFI}{Total\ vehicles/10,000} \right)$$

RNFITV = road non-fatal injuries per 10,000 vehicles
 RNFI = road non-fatal injuries
 Total vehicles = total number of vehicles

Potential data sources While national statistics on road fatalities are normally available, data on non-fatal injuries are harder to obtain and compare between countries. Ideally, non-fatal injuries are to be recorded and reported by the police, who are primarily responsible for providing first response to such incidences. However, such data is not always collected or reported by the police (WHO, 2015). Existing estimates are normally based on hospital records and are complemented/validated by police data (WHO, 2015).

Remarks While there are limitations in the existing data, these are still useful in terms of providing insights into the magnitudes of non-fatal injuries. The assessment of injury severity requires specialised training, which is not necessarily given to first responders, and makes data collection challenging.

Related indicators 9. Total road vehicles

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Annex 1. External links

Selected References	
1. Total population	ASEANStat https://data.aseanstats.org/static/SelectedKey/table1.xls UN Population Prospects https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html UN Population Databases http://www.un.org/en/development/desa/population/publications/database/index.shtml
2. Motorisation rates	AJTP Road Transport Statistics http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html ITPS and Clean Air Asia (2012) Long term action plan for ASEAN http://cleanairasia.org/study-of-long-term-transport-action-plan-for-asean-region-lpa-project OICA estimates http://www.un.org/en/development/desa/population/publications/database/index.shtml
3. Total VKM	BITRE (2012) Traffic Growth: Modelling a Phenomenon https://bitre.gov.au/publications/2012/files/report_128.pdf ITPS and Clean Air Asia (2012) Long term action plan for ASEAN http://cleanairasia.org/study-of-long-term-transport-action-plan-for-asean-region-lpa-project
4. VKM per capita	See Factsheets 1 and 3
5. Total PKM	AJTP Road Transport Statistics http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html Eurostat Passenger Mobility Guidelines https://circabc.europa.eu/sd/a/faf05533-b017-45ad-856f-f809fde4e0a8/Eurostat%20Passenger%20Mobility%20guidelines.pdf Eurostat Rail Transport Statistics Methodology http://ec.europa.eu/eurostat/documents/29567/3217334/Reference+manual+on+Rail+Transport+Statistics+%28Version+8.01%29/ed767b61-7fca-470a-a9e2-582e4aabedcb UK ORR Passenger Rail Usage: Quality and Methodology Report http://orr.gov.uk/__data/assets/pdf_file/0015/4371/passenger-usage-quality-report.pdf
6. PKM per GDP	Eurostat indicator definition and metadata http://ec.europa.eu/eurostat/cache/metadata/EN/tran_hv_pstra_esms.htm

7. Total tonne-kilometres

AJTP Road Transport Statistics

<http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html>

Allen, Brown, Cherrett (2012) Survey Techniques in Urban Freight Transport Studies

<http://www.tandfonline.com/doi/abs/10.1080/01441647.2012.665949>

Eurostat Manual on Road Freight Surveys

<http://ec.europa.eu/eurostat/documents/3859598/6494687/KS-GQ-14-007-EN-N.pdf>

Eurostat Road Freight Transport Methodology

<http://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-16-005>

Eurostat Rail Transport Statistics Methodology

<http://ec.europa.eu/eurostat/documents/29567/3217334/Reference+manual+on+Rail+Transport+Statistics+%28Version+8.01%29+ed767b61-7fca-470a-a9e2-582e4aabedcb>

UK ORR Freight Rail Usage: Quality and Methodology Report

http://orr.gov.uk/__data/assets/pdf_file/0016/22903/freight-usage-quality-report.pdf

8. Tonne-kilometres per GDP

Eurostat definition and meta-data

http://ec.europa.eu/eurostat/cache/metadata/en/tsdtr230_esmsip.htm

Gleave (2003) Freight Transport Intensity of Production and Consumption

http://www.europarl.europa.eu/stoa/webdav/shared/3_activities/transport/general/ipts_freight_en.pdf

See Factsheets 8 and 27.

9. Total road vehicles

ADB Transport DataBank

<http://transportdata.net/en>

AJTP Road Transport Statistics

<http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html>

ITPS and Clean Air Asia (2012)

<http://cleanairasia.org/study-of-long-term-transport-action-plan-for-asean-region-lpa-project>

10. Average occupancies – by passenger vehicle types

EEA Occupancy Rates of Passenger Vehicles

<https://www.eea.europa.eu/data-and-maps/indicators/occupancy-rates-of-passenger-vehicles/occupancy-rates-of-passenger-vehicles>

Eurostat Passenger Mobility Guidelines

<https://circabc.europa.eu/sd/a/faf05533-b017-45ad-856f-f809fde4e0a8/Eurostat%20Passenger%20Mobility%20guidelines.pdf>

Heidtman, et al. (1997)

<https://www.fhwa.dot.gov/ohim/veh-occ.pdf>

11. Average load- by freight vehicle types	<p>EEA Load Factors for Freight Transport https://www.eea.europa.eu/data-and-maps/indicators/load-factors-for-freight-transport</p> <p>Eurostat Manual on Road Freight Surveys http://ec.europa.eu/eurostat/documents/3859598/6494687/KS-GQ-14-007-EN-N.pdf</p> <p>Eurostat Road Freight Transport Methodology http://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-16-005</p>
12. Alternative-fuel vehicles proportion of the vehicle fleet	<p>EEA Alternative-fuel vehicles as a proportion of the total fleet https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehicle-fleet-meeting-4</p> <p>U.S. Department of Energy https://www.afdc.energy.gov/data/categories/vehicles</p>
13. Share of renewable energy in total road transport energy	<p>EEA Share of Renewable Energy in Final Energy Consumption https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-1</p> <p>IEA Energy Statistics Manual https://www.iea.org/publications/freepublications/publication/energy-statistics-manual.html</p>
14. Kilometre of road infrastructure	<p>ADB Transport DataBank http://transportdata.net/en</p> <p>AJTP Road Transport Statistics http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html</p> <p>Dulac (2013) Global Land Transport Requirements https://www.iea.org/publications/freepublications/publication/TransportInfrastructureInsights_FINAL_WEB.pdf</p>
15. Average fuel economy by vehicle type	<p>Global Fuel Economy Toolkit https://www.globalfueleconomy.org/in-country/gfei-toolkit</p> <p>U.S. Department of Energy http://fueleconomy.gov/</p> <p>International Council on Clean Transportation http://www.theicct.org/issues/fuel-economy</p>
16. Average Speed by vehicle type	<p>Hoogendoorn, S., and V. Knoop (2013) http://victorknoop.eu/research/papers/chapter_vanwee.pdf</p>

17. Total transport energy consumption

ADB Transport DataBank

<http://transportdata.net/en>

IEA Energy Statistics Manual

<https://www.iea.org/publications/freepublications/publication/energy-statistics-manual.html>

IEA Energy Balance of Non-OECD Countries

https://www.iea.org/publications/freepublications/publication/WorldTrends_NonOECD_countries2015.pdf

IEA World Energy Balance Documentation

http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf

IEA-UIC Railway Handbook

<https://www.iea.org/topics/transport/railwayhandbook/>

Institute of Energy Economics, Japan

<https://eneken.iecee.or.jp/en/>

IPCC Guidelines – Mobile Sources

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

18. Transport Energy Consumption per GDP

See Factsheets 17 and 27

19. Particulate matter emission factors by vehicle type

Air Pollutant Emission Factor Library

<http://www.apef-library.fi/>

Clean Air Asia (2012) Accessing Asia

<http://cleanairasia.org/accessing-asia-air-pollution-and-greenhouse-gas-emissions-from-road-transport-and-electricity/>

COPERT Model

<http://emisias.com/products/copert/copert-5>

EMEP/EEA Air Pollutant Emission Inventory Guidebook

<https://www.eea.europa.eu/publications/emep-eea-guidebook-2016>

GIZ (2014) Thailand Stocktaking Report

http://www.sutp.org/files/contents/documents/resources/B_Technical-Documents/GIZ-SUTP_TD_Thailand-Stocktaking-Report_EN.pdf

Global Air Pollution Forum Emission Manual

<https://www.sei-international.org/gap-the-global-air-pollution-forum-emission-manual>

International Vehicle Emissions Model

<http://www.issrc.org/ive/>

20. NOx emission factor per vehicle type	<p>Air Pollutant Emission Factor Library http://www.apef-library.fi/</p> <p>Clean Air Asia (2012) Accessing Asia http://cleanairasia.org/accessing-asia-air-pollution-and-greenhouse-gas-emissions-from-road-transport-and-electricity/</p> <p>COPERT Model http://emisias.com/products/copert/copert-5</p> <p>EMEP/EEA Air Pollutant Emission Inventory Guidebook https://www.eea.europa.eu/publications/emep-eea-guidebook-2016</p> <p>GIZ (2014) Thailand Stocktaking Report http://www.sutp.org/files/contents/documents/resources/B_Technical-Documents/GIZ-SUTP_TD_Thailand-Stocktaking-Report_EN.pdf</p> <p>Global Air Pollution Forum Emission Manual https://www.sei-international.org/gap-the-global-air-pollution-forum-emission-manual</p> <p>International Vehicle Emissions Model http://www.issrc.org/ive/</p>
21. Total Transport GHG emissions	<p>IEA CO₂ highlights 2017 https://www.iea.org/publications/freepublications/publication/co2-emissions-from-fuel-combustion-highlights-2017.html</p> <p>IEA & UIC Railway Handbook 2017 Energy Consumption and CO₂ Emissions https://uic.org/IMG/pdf/handbook_iaea-uic_2017_web2-2.pdf</p> <p>ITPS and Clean Air Asia (2012) Long term action plan for ASEAN http://cleanairasia.org/study-of-long-term-transport-action-plan-for-asean-region-lpa-project</p> <p>SLOCAT (2016) Transport GHG Methodology http://www.slocat.net/sites/default/files/slocat_transport_ghg_methodology_-_revised_sep_2016.xlsx</p> <p>UNFCCC Greenhouse Gas Data http://unfccc.int/ghg_data/items/3800.php</p>
22. Transport GHG Emissions per Capita	<p>IEA CO₂ highlights 2017 https://www.iea.org/publications/freepublications/publication/co2-emissions-from-fuel-combustion-highlights-2017.html</p>
23. Passenger transport GHG per PKM	<p>EEA Energy efficiency and specific CO₂ emissions https://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-9</p> <p>See Factsheets 21 and 5</p>

24. Freight Transport GHG per TKM	<p>EEA Energy efficiency and specific CO₂ emissions https://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-9 See Factsheets 21 and 7</p>
25. Road transport particulate matter emissions	<p>Clean Air Asia (2012) Accessing Asia http://cleanairasia.org/accessing-asia-air-pollution-and-greenhouse-gas-emissions-from-road-transport-and-electricity/ HEI Traffic Related Air Pollution https://www.healtheffects.org/air-pollution/traffic-related-air-pollution USEPA PM Pollution https://www.epa.gov/pm-pollution See Factsheet 19</p>
26. Road transport NOx emissions	<p>Clean Air Asia (2012) Accessing Asia http://cleanairasia.org/accessing-asia-air-pollution-and-greenhouse-gas-emissions-from-road-transport-and-electricity/ HEI Traffic Related Air Pollution https://www.healtheffects.org/air-pollution/traffic-related-air-pollution See Factsheet 20</p>
27. Gross domestic product	<p>ASEANStat https://data.aseanstats.org/static/Macroeconomic/table3.xls</p>
28. Freight rates	<p>BITRE Freight Rates in Australia https://bitre.gov.au/publications/2017/is_090.aspx</p>
29. Fossil fuel subsidy for transport	<p>IEA Energy Subsidies https://www.iea.org/statistics/resources/energysubsidies/ OECD Support Measures for Fossil Fuels http://www.oecd.org/about/secretary-general/oecd-inventory-of-support-measures-for-fossil-fuels-2015.htm</p>
30. Transport infrastructure investments	<p>OECD Infrastructure Investment Indicator https://data.oecd.org/transport/infrastructure-investment.htm World Bank Transport Investments (with private participation) https://data.worldbank.org/indicator/IE.PPI.TRAN.CD</p>





31. Climate finance for transport	<p>UNFCCC Webpage ‘Focus: Climate Change’ http://unfccc.int/focus/climate_finance/items/7001.php</p> <p>UNFCC Climate Finance Data Portal http://unfccc.int/climatefinance?home</p> <p>UNFCCC Webpage ‘Submitted BURs from Non-Annex 1 Parties’ http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php</p> <p>SLOCAT Climate Finance Transport Projects Matrix http://www.slocat.net/sites/default/files/climate_finance_transport_projects_matrix_1.8_-_2016-11-03.xlsx</p>
32. Road fatalities/ million vehicles	<p>AJTP Road Transport Statistics http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html</p> <p>UNECE Statistical Database http://w3.unece.org/PXWeb2015/pxweb/en/STAT/STAT__40-TRTRANS__01-%20TRACCIDENTS</p> <p>WHO Global Status Report on Road Safety http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/</p>
33. Road non-fatal injuries per 10,000 vehicles	<p>AJTP Road Transport Statistics http://www.ajtpweb.org/ajtp/statistics/roadtransport/index.html</p> <p>UNECE Statistical Database http://w3.unece.org/PXWeb2015/pxweb/en/STAT/STAT__40-TRTRANS__01-%20TRACCIDENTS</p> <p>WHO Global Status Report on Road Safety http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/</p>

Footnotes

- 1 These are based on the final list of proposed SDG indicators as noted in IAEG-SDG (2016).
- 2 Asterisk (*) refers to multiplication.
- 3 The United Nations, for example, defines population estimates as the mid-year medium estimates (as opposed to the high and low estimates). Mid-year estimates are also being used by the ASEANStat. http://www.un.org/en/development/desa/population/publications/pdf/policy/WPP2013/Chapters/f_Definitions%20of%20Population%20Indicators.pdf
- 4 [http://www.aseanstats.org/infographics/glossaries/#iLightbox\[gallery-rw-1\]/13](http://www.aseanstats.org/infographics/glossaries/#iLightbox[gallery-rw-1]/13)
- 5 These can be complemented using modern technologies for determining overall travel distances (e.g. GPS devices, mobile phones).
- 6 Eurostat website. http://ec.europa.eu/eurostat/cache/metadata/en/tran_hv_pstra_esms.htm#stat_pres1470732291994
- 7 GDP is expressed in Euro.
- 8 Light vehicles (equal or less than 3.5 tons) are excluded.
- 9 Such as liquid bulk, solid bulk, large freight containers, palletised goods, other freight containers.
- 10 European Environmental Agency website. <https://www.eea.europa.eu/data-and-maps/indicators/occupancy-rates-of-passenger-vehicles/occupancy-rates-of-passenger-vehicles-1>
- 11 Light vehicles (equal or less than 3.5 tons) are excluded.
- 12 Such as liquid bulk, solid bulk, large freight containers, palletised goods, other freight containers.
- 13 European Environment Agency website: <https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehicle-fleet-meeting-4>
- 14 http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Renewable_energy_sources
- 15 Open Cycle Map website. <http://www.opencyclemap.org/>
- 16 ASEAN website. http://asean.org/?static_post=annex-b-asean-highway-standards
- 17 This is based on the GFEI methodology.
- 18 ICCT website: <https://www.theicct.org/news/EU-real-world-vehicle-fuel-consumption-gap-all-time-high>
- 19 The chart presents average estimates per public transport vehicle type and average route distance.
- 20 A useful on-line tool is the IEA unit converter : <https://www.iea.org/statistics/resources/unitconverter/>
- 21 For electric vehicles, kWh/km replaces FE, and the calorific value is dropped.
- 22 Default calorific values can be sourced from table 1.2 of chapter 1 of the energy section of the 2006 IPCC guidelines: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf
- 23 Eurostat website. http://ec.europa.eu/eurostat/cache/metadata/EN/tsdtr100_esmsip.htm
- 24 GDP is presented as current prices in US dollars.
- 25 The Fifth Assessment Report of the IPCC (also commonly referred to AR5) estimates the following GWP values in terms of CO₂ equivalents: CO₂ = 1; CH₄ = 28; N₂O = 265.
- 26 See page 3.42 of chapter 3 of volume 2 of the guidelines : https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

- 27 UNFCCC website. http://unfccc.int/ghg_data/items/3800.php or through http://di.unfccc.int/ghg_profile_non_annex1 . The UNFCCC categorises transport under the energy sector.
- 28 IEA CO2 Highlights 2017. <https://www.iea.org/publications/freepublications/publication/co2-emissions-from-fuel-combustion-highlights-2017.html>
- 29 European Database for Global Atmospheric Research website: <http://edgar.jrc.ec.europa.eu/>
- 30 The Fifth Assessment Report of the IPCC (also commonly referred to AR5) estimates the following GWP values in terms of CO2 equivalents: C_{O2 =1; CH4 = 28; N2O=265.}
- 31 A passenger kilometre is a measure of passenger transport activity which refers to the carriage of a passenger for one kilometre.
- 32 European Environment Agency website: <https://www.eea.europa.eu/data-and-maps/figures/specific-co2-emissions-per-passenger-3>
- 33 The Fifth Assessment Report of the IPCC (also commonly referred to AR5) estimates the following GWP values in terms of CO2 equivalents: C_{O2 =1; CH4 = 28; N2O=265.}
- 34 Asterisk (*) refers to multiplication.
- 35 A passenger kilometre refers to the carriage of a passenger for one kilometre.
- 36 The Fifth Assessment Report of the IPCC (also commonly referred to AR5) estimates the following GWP values in terms of CO₂ equivalents: CO₂ =1; CH₄ = 28; N₂O=265.
- 37 Primary particles are produced directly through physical and chemical processes, while secondary particles are formed through chemical and physical reactions of gases in the atmosphere (Vallack & Rypdal, 2012).
- 38 Eurostat website. http://ec.europa.eu/eurostat/statistics-explained/index.php/National_accounts_and_GDP
- 39 OECD data website. <https://data.oecd.org/transport/infrastructure-investment.htm>
- 40 OECD data website. <https://data.oecd.org/transport/infrastructure-investment.htm>
- 41 <http://unfccc.int/climatefinance?home>
- 42 <http://www.slocat.net/news/1447>
- 43 See the submissions of Indonesia, and Viet Nam as examples : http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php
- 44 World Health Organization Website. http://www.who.int/topics/injuries_traffic/en/
- 45 World Health Organization Website. http://www.who.int/gho/road_safety/en/
- 46 http://www.who.int/topics/injuries_traffic/en/

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