International Transport Forum

Implementing the ASEAN Fuel Economy Roadmap

Case-Specific Policy Analysis

Implementing the ASEAN Fuel Economy Roadmap

Case-Specific Policy Analysis

The International Transport Forum

The International Transport Forum is an intergovernmental organisation with 63 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. ITF is the only global body that covers all transport modes.

The ITF is politically autonomous and administratively integrated with the OECD. The ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

The ITF organises global dialogue for better transport. We act as a platform for discussion and prenegotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision-makers and civil society. The ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

The Members of the Forum are: Albania, Armenia, Argentina, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, China (People's Republic of), Colombia, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Kazakhstan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Republic of Moldova, Mongolia, Montenegro, Morocco, the Netherlands, New Zealand, North Macedonia, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine, the United Arab Emirates, the United Kingdom, the United States and Uzbekistan.

International Transport Forum
2 rue André Pascal
F-75775 Paris Cedex 16
contact@itf-oecd.org
www.itf-oecd.org

Case-Specific Policy Analysis Reports

The ITF's Case-Specific Policy Analysis series presents topical studies on specific issues carried out by the ITF in agreement with local institutions. Any findings, interpretations and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the International Transport Forum or the OECD. Neither the OECD, ITF nor the authors guarantee the accuracy of any data or other information contained in this publication and accept no responsibility whatsoever for any consequence of their use. This report is published under the responsibility of the Secretary-General of the ITF. It is the result of a joint collaboration between the Association of Southeast Asian Nations (ASEAN), FIA Foundation, Global Fuel Economy Initiative (GFEI) and ITF, as the project partners. The opinions expressed and the arguments employed herein do not necessarily reflect the official views of project partners.

countries or states and member organisations, but ask that proper acknowledgement is given to all project partners and that any outputs making use of the report are shared with the project partners.

This report, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Cite this work as: ITF (2022), "Implementing the ASEAN Fuel Economy Roadmap", *International Transport Forum Policy Papers*, No. 102, OECD Publishing, Paris.

Acknowledgements

The lead author of this report is Pierpaolo Cazzola. The project was managed by Pierpaolo Cazzola and Wei-Shiuen Ng, supported by Till Bunsen and Matteo Craglia. This project, which is part of the ITF-ASEAN Transport Research initiative, was jointly developed by the ITF and the ASEAN Land Transport Working Group (LTWG), led by Singapore, and it is included in the ASEAN Land Transport Working Group's 2020 Work Programme. Bert Fabian and Ji-Hee Kim with the United Nations Environment Programme (UNEP) supported the planning of the project workshops and shared information and experience of the Global Fuel Economy Initiative's (GFEI) activities in the region.

The analysis draws upon desk research and insights from two workshops co-organised by the ITF, the ASEAN Secretariat and the UNEP. These were held on 27 January and 1 September 2021 as virtual events. They gathered representatives from all ten ASEAN Member States involved in the work of the ASEAN LTWG. This project benefited from the responses to the Questionnaire on Fuel Economy Policies in ASEAN Member States submitted by the ministries of transport from the following ASEAN Member States: Brunei Darussalam, Indonesia, Lao People's Democratic Republic (PDR), Myanmar, Philippines, Singapore, Thailand and Viet Nam. Responses to the questionnaire from Cambodia were submitted by Clean Air Asia and from Malaysia by Focus Applied Technologies. In particular, the project benefited from the input of the following individuals: Megasari Widyaty, Beny Irzanto, Rasyid Indra Pratama (ASEAN Secretariat); Danawiryya Silaksanti (Ministry of Transportation, Indonesia); Ratna Kartikasari (Ministry of Environment and Forestry, Indonesia); Yusuf Nugroho (Ministry of Transportation, Indonesia); Rinna Santi Sijabat (Ministry of Energy and Mineral Resources, Indonesia); Risal Wasal (Ministry of Transportation, Indonesia); Mario U. Tercero (UNDP-DOTr, Philippines); Department of Transportation, Philippines; Department of Trade and Industry, Philippines; Department of Science and Technology, Philippines; Annabelle V. Briones (DOST-ITDI, Philippines); Department of Environment and Natural Resources, Philippines; Patrick T. Aquino (Philippine Department of Energy, Philippines); Chutinthorn Mankhong (Ministry of Transport, Thailand); Eu Jun Toh (Land Transport Authority, Singapore); Xaysomnuk Souvannavong (Ministry of Public Works and Transport, Lao PDR); Nguyen Huu Tien (Ministry of Transport, Viet Nam); Automotive Engineering Bureau (Department of Land Transport, Thailand); Muhammad Herman bin Abdullah Sebi (Ministry of Transport and Infocommunications, Brunei Darussalam); Nwe Nwe Khin (Road Transport Administration Department, Myanmar); Madan Regmi (UNESCAP); Myo Naing (Road Transport Administration Department, Myanmar); Kathleen Dematera Contreras (Clean Air Asia); Horizon Gitano-Briggs (Focus Applied Technologies), and Glynda Bathan-Baterina (Clean Air Asia).

Other valuable insights were also offered during the review process by François Cuenot (United Nations Economic Commission for Europe) and GFEI partners, including Bert Fabian (UNEP), Zifei Yiang (International Council for Clean Transportation), Jacob Teter (International Energy Agency [IEA]), Apostolos Petropoulos (IEA), Alison Pridmore (IEA) and Sheila Watson (FIA Foundation) and Richard Clarke (FIA Foundation).

Beny Irzanto (ASEAN Secretariat) and Eu Jun Toh (Land Transport Authority, Singapore) also offered valuable contributions and insightful comments during the review process.

At the ITF, Wei-Shiuen Ng, Matteo Craglia and Till Bunsen provided comments. Credits also go to Jari Kauppila and Stephen Perkins for their support throughout the project and their comments. Suzanne Parandian (independent) copy-edited the report, and Hilary Gaboriau (ITF) co-ordinated publication.

This project is funded by the FIA Foundation.

Table of contents

Figures

Tables

Boxes

Executive summary

What we did

This study provides support for implementing the Association of Southeast Asian Nations' (ASEAN) "Fuel Economy Roadmap for the Transport Sector 2018-2025: with Focus on Light-Duty Vehicles" (hereinafter referred to as "ASEAN Fuel Economy Roadmap"), which is key to sustainable transport in the region. It examines policies for making light-duty vehicles more energy-efficient and less carbon dioxide (CO_2) emitting and also provides insights for other motorised road vehicles. The report explores opportunities for aligning policies across ASEAN, considers the role of trade facilitation agreements and recommends measures for a transition towards electrification.

What we found

The ASEAN fuel economy roadmap, developed and adopted by ASEAN transport ministers in 2018, outlines a vision to transform the light-duty vehicle market in the ASEAN region into one of the world's most fuel-efficient. The roadmap sets out six aspirational goals to help achieve this objective, starting from the principal target of reducing the average fuel consumption of new light-duty vehicles sold in ASEAN by 26% between 2015 and 2025.

Successful implementation of the ASEAN fuel economy roadmap requires a step-change in policy-making. A significant gap exists between objectives and the current situation in ASEAN Member States. Policies related to fuel economy, pollutant emission control and low and zero-emission vehicles (LZEVs) in the region are still heterogeneous and determined by the individual circumstances of ASEAN Member States.

Two factors stand out among the determinants for national policy frameworks: countries' endowment with different natural resources and local investment by the automotive industry and policies for its development. The presence of a car industry generally goes along with some actions to promote better fuel economy or develop a market for LZEVs. However, fuel economy policies in the ASEAN region are less robust than in other major global markets and do not include regulatory frameworks.

The presence of oil resources or a domestic oil industry tends to be associated with subsidies for, or weaker taxation of, oil products for road vehicles. Another rationale for fuel subsidies is reducing transport and supply chain costs. Such subsidies tend to impact fuel economy negatively, since they reduce opportunities for energy-efficient technologies to deliver net savings on the total cost of vehicle ownership and operation. In turn, this limits demand for vehicles with better energy efficiency.

ASEAN Member States have already aligned their policy frameworks on tailpipe emissions of local pollutants. All ASEAN Member States have adopted a common procedure for measuring emissions of local pollutants from light-duty vehicles. However, they could be still more ambitious. Room for improvement exists with regard to imported second-hand vehicles, for instance. All ASEAN Member States apply at least Euro 4 limits on pollutants. In Europe, Euro 4 was superseded by the more stringent Euro 5 in 2009 and by Euro 6 in 2014.

The ASEAN Mutual Recognition Arrangement on Type Approval for Automotive Products (APMRA), a trade facilitation agreement, was a significant driver of this alignment, along with environmental policies to reduce local pollutants.

What we recommend

Strengthen alignment on fuel economy measurement as a key prerequisite for further action

Establishing a common approach to measuring fuel economy and direct CO_2 emissions of vehicles is necessary for targeted and effective initiatives. Several ASEAN Member States (Indonesia, Malaysia, Singapore and Thailand) are already using the United Nations (UN) Regulation 101 as the technical reference for the measurement of fuel economy and emissions of CO_2 per kilometre (CO_2/km). Adopting UN regulations will be central to the success of the ASEAN fuel economy roadmap. Adoption could occur through unilateral action by each ASEAN Member State or through integrating the relevant national regulatory texts into the framework of the APRMA trade facilitation agreement. The choice of texts to incorporate into APRMA should ensure that the regulation will be resilient to future technological changes, such as introducing LZEVs and capturing the advantages resulting from closer global regulatory harmonisation. In particular, UN Regulation 154 (based on the up-to-date Worldwide Harmonised Light-Duty Test Procedure [WLTP]) would be a better choice than UN Regulation 101 for measuring fuel economy, as roadmaps for the adoption of Euro 6 are drafted, and e-mobility is being mainstreamed. Involvement in the World Forum for Harmonization of Vehicle Regulations (WP.29) activities would help ASEAN Member States progress on these points.

Ensure availability of testing capacity for fuel economy

ASEAN Member States need to build the capacity for carrying out test procedures to verify compliance with fuel economy regulations. They must identify the responsible authorities, designate required technical services and provide necessary resources. These actions are in line with APRMA (Article 7), which underlines the fact that integrating the regulation for measuring fuel economy or CO_2 emissions within its framework is a valuable decision.

Build data processing and storage capacity for benchmarking, monitoring and decision making

ASEAN Member States should develop the capacity to systematically record and process available vehicle data. Data collection should cover all vehicles entering the market and use the same vehicle categories across the region. ASEAN Member States should designate which authorities should provide and maintain the data legally to ensure that they are reliable, up-to-date and made available at regular intervals. Transparency vis-à-vis the public will ensure that the accuracy and credibility of the data are verifiable. The ability to capture, store and process data is fundamental for establishing benchmarks, monitoring progress over time and, ultimately, informing fuel economy and environmental policies.

Adopt and align policy tools to strengthen ASEAN fuel economy ambition

Several instruments can enable ASEAN Member States to strengthen their ambition while harmonising their fuel economy framework. These instruments include creating a common fuel economy label for vehicles, harmonising economic incentives or penalties, and developing an ASEAN-wide fuel economy standard. ASEAN should apply these instruments to new vehicles, as well as second-hand imports since the overall fuel consumption depends on both. If each ASEAN Member State develops effective mechanisms on a national level, they would miss out on the benefits from harmonisation, notably the scale effects that will reduce costs and facilitate compliance.

Align fuel taxation policies across ASEAN

Aligning fuel taxation regimes in the region would improve its fuel economy. A common approach should be to eliminate fossil fuel subsidies as a minimum. To be more effective, aligned fuel taxes should incorporate a gradually increasing carbon price. If complete harmonisation is infeasible, the aim should then be to increase convergence based on an agreed timeline and defined milestones.

Include low- and zero-emission vehicles in the ASEAN fuel economy roadmap

Policies supporting the uptake of LZEVs are currently not a focus of the ASEAN fuel economy roadmap. However, LZEVs are essential for achieving energy efficiency, decarbonisation and economic development in the region. Support for LZEVs should target vehicle uptake, infrastructure development and accessibility of new energy vectors, such as decarbonised electricity. This requires setting technical standards for safety and environmental performance, for which work within the UN framework can provide guidance. Importantly, LZEVs policies should apply a life-cycle approach, i.e. to cover their upstream and downstream impacts, as well as their direct emissions.

Target all motorised vehicles with policies that reduce fuel consumption and CO_2 emissions

Progress in measuring fuel economy is critical for achieving the ASEAN fuel economy roadmap's primary objective, which is to create more energy-efficient light-duty vehicles. However, it is equally important for other road vehicles. These include two-wheelers, three-wheelers, buses, and commercial vehicles, such as heavy-duty vehicles. The policies for fuel-efficient light-duty vehicles will also apply to these other types of vehicles, with some adjustments. Targeting light-duty vehicles and other road vehicles will therefore create greater impact on total fuel consumption and CO_2 emissions reduction.

Introduction

Anthropogenic climate change is pushing the earth's climate into an unprecedented state, leading the UN Secretary-General, António Guterres, to describe the latest findings of the Intergovernmental Panel on Climate Change (IPCC) as "code red for humanity" (UN, 2021). The transport sector remains one of the largest contributors to climate change, accounting for 24% of direct CO_2 emissions from fuel combustion in 2019 (IEA, 2020). Transport sector emissions in the ASEAN region, comprising Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam accounted for roughly 5% of global transport CO_2 emissions in 2019 (ITF, 2021a).

Limiting the damaging effects of climate change requires collective action by all countries, with the Glasgow Climate Pact adopted at the 2021 UN Climate Change Conference (COP26) explicitly emphasising "the urgent need for Parties to increase their efforts to collectively reduce emissions through accelerated action and implementation of domestic mitigation measures (…)" and the phasing out of subsidies for fossil fuel (UNFCCC, 2021).

There is a mix of developed and developing economies in the ASEAN region, with varying rates of recovery already having been observed after the Covid-19 pandemic (OECD, 2021; World Bank, 2021). However, prospects for future transport demand increases in the ASEAN region are clear. By 2050, the population of Southeast Asia is expected to exceed 790 million, a nearly 20% increase over 2020 levels (UN DESA, 2019). Economic growth is expected to accompany the growing population, with an expanding middle class and increased consumption (WEF, 2020). According to transport demand modelling conducted by the International Transport Forum (ITF, 2021a; ITF, 2022), passenger transport demand in ASEAN countries is expected to grow over the next three decades, more than tripling between 2015 and 2050. Similar considerations apply to freight transport, which will grow by a factor of about four over the 2015 figure of 8.9 trillion tonne-kilometres (tkm).

Vehicles serving road passenger transport in the ASEAN region accounted for 73% of total passenger mobility expressed in passenger-kilometres (pkm) in 2015. In a baseline scenario that reflects the impacts of announced policy actions, direct emissions from road passenger vehicles will increase from roughly 150 million tonnes (Mt) to almost 340 Mt of CO_2 between 2015 and 2050 (ITF, 2021a; ITF, 2022). Roughly half of the direct CO_2 emissions from passenger transport were from car travel in 2015, increasing to approximately 60% in 2050 under a baseline scenario. This is despite a significantly smaller share (close to a third) of passenger activity due to their higher carbon intensity in comparison with other modes. Similarly, road freight accounts for half of all direct CO_2 emissions from the freight transport sector across the whole projection period up to 2050, well above the 8-10% contribution in terms of activity tonne-kilometres (ITF, 2021a; ITF, 2022).

These projections highlight that greater policy action is needed to ensure that the expected growth in transport and economic activity is not paired with higher environmental impacts. ITF scenarios indicate that travel demand management, energy efficiency and the decarbonisation of the energy used by transport vehicles are crucial to achieving this goal on both a global and regional scale (ITF, 2021a; ITF, 2022).

The importance of acting to cut emissions from passenger and freight vehicles, particularly passenger cars, is clearly reflected in the political decision that led to the definition and approval of the ASEAN fuel economy roadmap, further outlined in Box 1.

Box 1. The ASEAN fuel economy roadmap

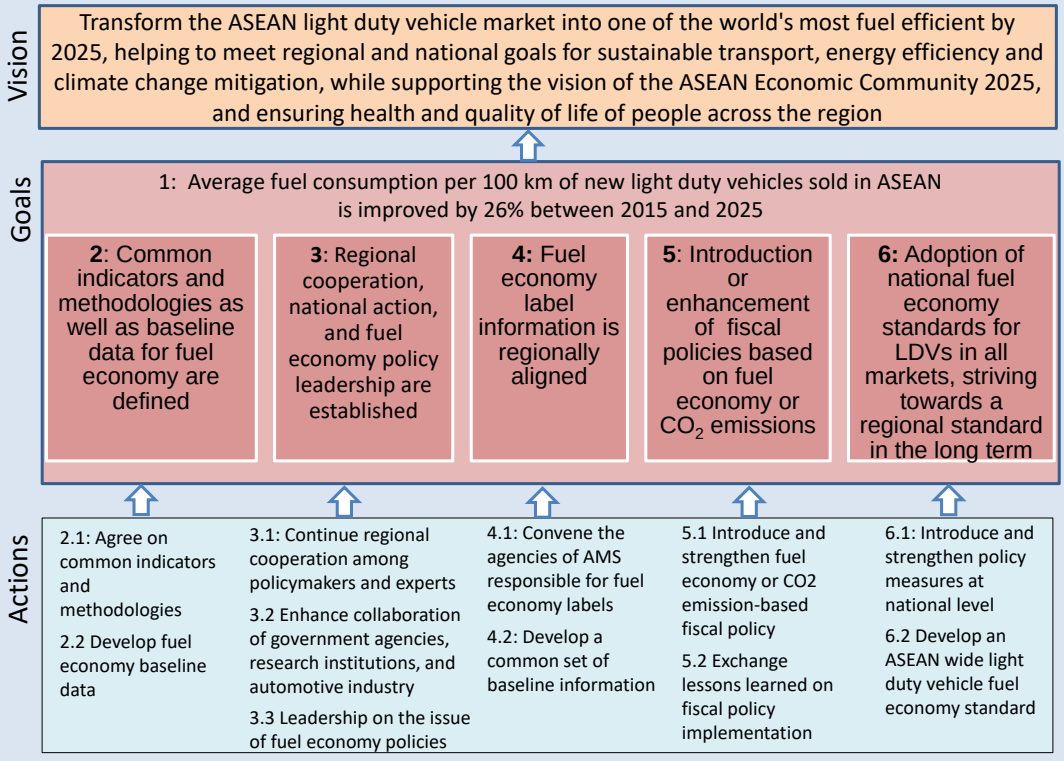
The ASEAN Fuel Economy Roadmap for the Transport Sector 2018-2025: with Focus on Light-Duty Vehicles (hereinafter referred to as ASEAN fuel economy roadmap), developed and adopted by ASEAN transport ministers in 2018[1], outlines a vision aiming to transform the light-duty vehicle market in this free-trade area into one of the world's most fuel efficient (ASEAN, 2019).

The roadmap sets six aspirational goals, starting from the principal target of reducing the average fuel consumption of new light-duty vehicles sold in ASEAN by 26% between 2015 and 2025. These goals also integrate the following key policy-making steps and practices:

- the development of common indicators and baselines
- enhanced regional co-operation
- the development of labelling schemes
- the adoption of fiscal policies
- the adoption of fuel economy standards

Further details, including specific actions supporting the implementation of these goals, are summarised in Figure 1.

Figure 1. The ASEAN fuel economy roadmap 2018-2025: Vision, goals and actions



Source: Toh (2021).

The roadmap is one of the instruments envisaged by ASEAN Member States to support implementation of the Kuala Lumpur Strategic Plan 2016-2025 (ASEAN, 2015). This includes the goal to establish an

efficient, safe and integrated regional land transport network, within ASEAN and with neighbouring countries, to support the development of trade and tourism. The roadmap responds to a specific call to intensify regional co-operation in the development of sustainable transport-related policies and strategies.

In addition to the vision, goals and actions identified in the ASEAN fuel economy roadmap, other measures, specifically targeting low- and zero-emission vehicles (LZEVs)[2], can also offer meaningful contributions to energy efficiency (and therefore fuel economy) improvements. In particular, specifically designed economic incentives or penalties for vehicles with high fuel consumption along with regulatory instruments can help to promote the adoption of electric vehicles (EVs).

EVs are clearly gaining importance globally due to their capacity to contribute to energy diversification and emission reduction in transport, as well as their strategic relevance in an emerging value chain (e.g. battery manufacturing) for industrial development and economic growth. If paired with renewable electricity (which is also gaining relevance globally due to its low cost), EVs are one of the most important opportunities to help align transport sector emissions with the ambition of the Paris Agreement.

These considerations point to an expanding role for the work of transport ministries in the context of decarbonisation. The analysis of this report builds on these strategic considerations with the goal of helping ASEAN and its member states realise the ambition outlined in the fuel economy roadmap. The report also includes recommendations on policy actions having a specific relevance for LZEVs, complementing the vision of the fuel economy roadmap.

The analysis developed in this report is structured as follows:

- The following chapter reviews international experiences regarding actions aiming to improve fuel economy and the transition towards cleaner vehicles, paying specific attention to the case of light-duty vehicles, which are the focus area of the ASEAN fuel economy roadmap. This is relevant for ASEAN Member States to gain a better understanding of which policies have been used internationally to make progress on fuel economy improvements and LZEV deployment, and why.
- The subsequent chapter contains an analysis of current policies in the ASEAN region that are directly or indirectly related to fuel economy improvements, integrating specific considerations on LZEVs.
- The final chapter identifies policy gaps relative to the roadmap and proposes concrete recommendations for the ASEAN and its member states to make progress on its implementation. This section also includes considerations on potential avenues for the integration of LZEVs in the ASEAN vehicle fleet.

Improving fuel economy: The international experience

Key policies for cleaner vehicles and energy vectors

Policies promoting the adoption of cleaner vehicles were first developed in the 1970s in the United States, and later adopted in other jurisdictions. The initial focus was on the management of local pollutants. Interest then shifted to energy efficiency during the oil shocks, and more recently – as climate change mitigation gained importance – to greenhouse gas (GHG) emission abatement.

A significant body of policy instruments has now been introduced across many economies to improve fuel economy and reduce GHG emissions, complementing actions aiming to improve air quality and increase energy security through energy diversification, which adds to energy efficiency benefits.

Several countries or groups of countries that have put such policies in place include Canada, the People's Republic of China, the European Union, India, Japan, Korea, Mexico, Saudi Arabia, the United Kingdom and the United States. The following sections briefly outline the type of actions undertaken, enabling learning from these experiences.

Fuel efficiency policies

Crucial parts of a successful policy framework to stimulate the deployment of fuel efficient and low-carbon vehicles and energies include (ITF, 2021b):

- Technical standards and regulations to ensure that the environmental characteristics of vehicles and their energy sources are clearly defined, objectively measured and communicated to vehicle users (e.g. through labelling schemes), in addition to safety-related requirements.
- A conducive energy pricing and taxation environment, where energy sources with poorer performance with respect to environmental targets (in particular, climate change) are subject to higher tax rates than alternative (and more sustainable or low carbon) forms of energy.
- The use of economic incentives or penalties to reduce the costs of clean vehicle technologies and increase their value proposition. These could come in the form of differentiated taxation for vehicle acquisition and circulation, based on environmental performance with respect to tailpipe emissions of GHGs and local pollutants.
- Regulatory requirements, in particular fuel economy or GHG emission standards.

Fuel economy or GHG emission standards are especially important for energy efficiency (and therefore GHG emission reductions), for the following reasons:

- They are durable. Fuel economy standards came into existence for cars as early as 1975 in the United States, via the Corporate Average Fuel Economy standards. Many other jurisdictions followed suit: Japan in 1999 (with the inclusion of cars in the Top Runner programme), China in 2004, the European Union in 2009 (following poor results from a voluntary agreement with car manufacturers), and India in 2014. These standards are now also widely applied to heavy goods vehicles (Greene, Greenwald and Ciez, 2020; IEA/GFEI, 2021; TransportPolicy.Net, 2021).

- They have a demonstrated record of effectiveness, despite room for improvement in ambition (Greene, Greenwald and Ciez, 2020; GFEI, 2020; IEA/GFEI, 2021).
- To date their unintended consequences e.g. on equity, safety (poorer vehicle performance in case of accidents), vehicle use patterns and increases in mileage were good or relatively small (Greene, Greenwald and Ciez, 2020).
- They can be easily implemented in parallel with other complementary regulatory instruments, such as those related to pollutant emissions, carbon intensity and quality of the fuels, enabling the regulation of multiple environmental impacts at the same time, taking a life-cycle perspective.

Additional measures can be implemented that focus on energy use and GHG emissions during vehicle manufacturing and end-of-life treatment. However, these do not generally have a strong impact on the fuel economy of internal combustion engine vehicles, except in cases where they promote material substitution leading to light-weighting, which needs to be balanced with potential changes to the energy needed for their manufacturing, including components, assembly and end-of-life management.

Policies focused on low- and zero-emission vehicles

Other policy instruments, also relevant for energy efficiency and fuel economy, have a specific focus on LZEVs. These include technologies that are currently experiencing rapid growth globally, such as plug-in hybrid and battery electric vehicles. They generally also include other options – namely fuel cell electric vehicles – that have not yet gained significant market share due to the difficulty in offering net savings on the total cost of ownership, supplemented by lower energy efficiency and higher GHG emissions of competing alternatives, in particular battery electric vehicles.

The transition towards LZEVs requires environmental technical standards aimed at limiting tailpipe and other emissions (e.g. from tyre and brake wear) of local pollutants, which are important to deliver co-benefits for air quality. It also requires safety standards for specific components such as batteries and hydrogen storage tanks, as well as public procurement programmes be in place to mobilise supply.[3] This transition also relies on the use of economic incentives (e.g. in the form of penalties for high fuel consumption vehicles) to encourage demand for low-emission options (on both vehicle purchase and circulation tax, as well as on parking and charges for road use). In addition, the integration of minimum requirements in terms of market shares in fuel economy and GHG emission per kilometre standards or mandates for LZEV deployment should be included. Other regulations are related to access restrictions (e.g. via waivers applied to LZEVs), typically in urban areas. Some regulatory measures may also be better implemented if they require a quicker technological transition for vehicles with high annual mileage.[4]

Additional measures (Box 2) need to address other aspects of the LZEV deployment, less related to direct environmental impacts due to their use, but still relevant to ensure that the reduction of the environmental impacts of vehicles activities follows a life-cycle approach. These other measures are also more closely related to steps needed to integrate LZEVs in the energy system so that they can effectively access low-carbon energy.

Box 2. LZEV policies looking beyond direct environmental impacts

The deployment of infrastructure allowing access to new energy vectors (i.e. electricity, for plug-in hybrids and battery electric vehicles, and hydrogen, for fuel cell vehicles) is crucial to ensure that LZEVs can be meaningfully deployed and used. This could be achieved with the following measures.

- dedicated technical standards for safety and environmental performance

- economic instruments aiming to ease investment risks for charging or refuelling infrastructure deployment
- regulatory instruments that mandate minimum availability in buildings, cities or urban agglomerations and along major road axes.

LZEV policies also need to make sure that the carbon intensity of all energy vectors used in transport can promote an effective shift towards low-carbon options. This requires policies around low-carbon fuel standards and renewable energy mandates (or electricity quotas), as well as policies that give priority to renewable electricity dispatching.

The manufacturing process for LZEVs also needs to align well with sustainability and environmental requirements, while ensuring that the quality of their components is reliable and fit for a circular economy approach. This is achieved via regulations on batteries, their performance and carbon footprint, and could also be extended in scope to include fuel cell systems. This also applies to the sustainable extraction and processing of the minerals needed to manufacture these devices and manage them in their second-life application or at the end of their useful life.

Regulatory measures related to sustainable finance[5] are also an important complement to the set of policies being developed in the transport and energy fields, as they are crucial for shifting investment to the production of LZEVs, low-carbon energy and charging or refuelling infrastructure.

Integrating LZEVs into energy systems can also improve the resilience of energy systems. Targeted policies on the functioning of the electricity market are important enablers of this development.

LZEV-related policies also need to consider impacts of structural changes in government revenues from fossil fuel taxation (or expenditures, in countries subsidising fuels), the need to rely on a novel set of primary materials (such as metals and minerals needed in batteries), and indirectly substituting fossil energy. As with digital technologies, they also need to manage impacts related to job creation (from LZEV manufacturing and electricity – or eventually hydrogen production, transport and distribution) and destruction (from the decline in internal combustion engine vehicles and pathways reliant on fossil energy) (ITF, 2021b).

Governance and clean vehicle policy action across different administrative levels

Policies aiming to promote the energy efficiency of road vehicles involve instruments introduced and enforced at different administrative levels. Due to the continental (if not global) nature of the vehicle market and the large amounts of capital needed to invest in fuel-saving technologies, it is common practice to see policy instruments promoting fuel economy improvements adopted at an administrative level, allowing a uniform application across large markets.

Technical standards are often part of this group. This is due to the technical nature, complexity, high development costs and significant contributions from industry, alongside government officials, in the development of these instruments. A clear illustration of this is the case of the UN's World Forum for the Harmonisation of Vehicle Regulations (WP.29), which, since its inception in the 1950s, has developed nearly 200 regulations, rules or global technical regulations (GTRs) regarding the safe and environmentally sound construction and operation of motorised road vehicles. Other examples include the work of international standardisation authorities, in particular the International Organization for Standardisation

(ISO), the International Electrotechnical Commission (IEC) or, in the case of North America, the Society of Automotive Engineers (SAE).

Regulatory requirements limiting pollutant and GHG emissions are also in this pool, as illustrated clearly by the examples of the European Union and the close alignment of regulatory requirements in Canada and the United States. This is due to the cross-national nature of car markets, especially in free trade areas (and related opportunities for economies of scale).

Supra-national adoption of economic incentives or penalties, such as differentiated vehicle acquisition or circulation taxes can also lead to net benefits for product planning and economies of scale, although they can be limited by institutional barriers and the subsidiarity principle, for example in Europe, where national governments oversee fiscal policies.

Other policy instruments are enforced locally, for example, policies that price or regulate the use of road space (e.g. parking areas) and network, as they are better managed by local authorities with greater exposure and proximity to specific locations and geographical areas.

The central role of measuring fuel economy performance

Measuring the performance of vehicles in terms of energy use, tailpipe GHG emissions and other environmentally related parameters (e.g. emission of local pollutants) is a crucial step required for fuel economy and other environmental policy developments, at all levels of governance and for all types of policy tool.

The key reason for this is that all benchmarking/baselining and progress tracking exercises, as well as any policy instrument applying differentiated treatments to vehicles, need to be able to do so based on objective, realistic (i.e. capable to reflect real driving conditions) and reproducible tests. The latter are essential to ensure the objectivity and scientific accuracy that need to underpin legislative decisions.

Depending on the parameters being checked (e.g. emissions of local pollutants or GHG emissions per km), tests are performed under laboratory conditions (this is still often the case for fuel economy and tailpipe GHG emissions/km) or using on-road measurements (so far mostly relevant for real-world pollutant emission measurements), or both. An overview of recent developments and key test cycles used in the case of cars and vans is discussed in Box 3.

Box 3. Procedures for measuring vehicle fuel economy and pollutant emissions

Standardised test procedures are used to measure vehicle fuel consumption, CO_2 and exhaust emissions of local pollutants, which include carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM) and nitrogen oxides (NO_X). To ensure reproducibility, these tests have been initially conceived and developed for laboratory conditions and driving cycles that are thoroughly defined by a range of technical parameters and conditions. Typical examples include speed, acceleration and the operating conditions of the vehicle as well as the testing environment.

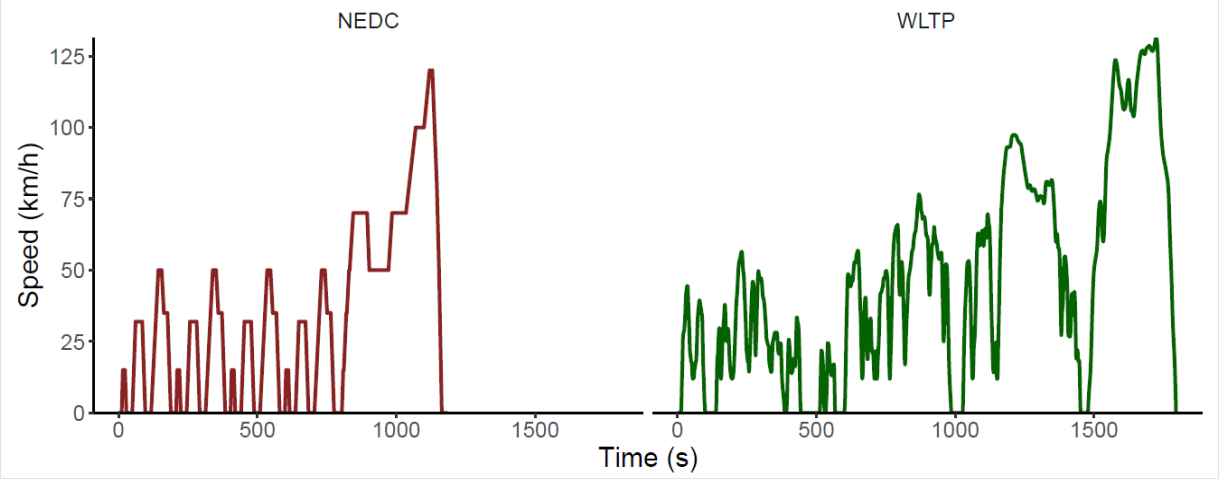
The New European Driving Cycle (NEDC; see Figure 2) started to be used in the European Union in 1997 and, as shown in Table 1 and Table 2 below, was then picked up in several other countries. Different drive cycles have been adopted for vehicle emission testing in the United States and elsewhere. Similarly, Japan used an independently developed cycle, known as the JC08 cycle (IEA, 2019).

The identification of growing discrepancies between real-world driving and the standardised conditions defined for the cycles, pointing to large underestimations of emissions in laboratory conditions, has led

to several updates and improvements (Greene et al., 2017; Fontaras, Zacharof and Ciuffo, 2017). In 2008, the American Corporate Average Fuel Economy (CAFE) cycles were changed to a five-cycle test including periods with air conditioning use, aggressive driving and cold temperature driving. In Europe, the NEDC was replaced by the Worldwide Harmonised Light-Duty Test Procedure (WLTP) and its associated drive cycle, the WLTC (Figure 2). The latter also replaced the JC08 of Japan, marking the start of an important effort to better harmonise test procedures globally.

Other tests have also been introduced since 2008 to reduce chances of mismatches, gaming and inaccuracies that may occur during laboratory testing. This work continued over the following decade, including following the fraud that emerged in 2015 with the "dieselgate" scandal (Jung and Sharon, 2019). An important development in this context was the introduction of "Real Driving Emissions" (RDE) testing, based on the use of Portable Emission Measurement Systems (PEMS) and intended to complement laboratory testing to ensure better alignment between legal requirements and real-world performance. Other important developments targeted increased stringency for in-service compliance.

Figure 2. Drive cycles used for fuel economy and air pollutant emission testing



Source: Craglia (2020).

The role of technical regulations in the accurate measurement of a vehicle's environmental performance

While there is universal consensus about using objective, realistic and reproducible tests, the approaches to testing, verifying compliance and setting minimum performance requirements are not uniform globally. A summary of procedures that have been or are currently being used to measure fuel economy and GHG emission/km of light-duty vehicles in major automotive markets are included in Table 1 and Table 2.

Technical regulations are the legal texts that outline which test procedures need to be applied to undertake fuel economy, CO_2 emissions/km and other pollutant emission measurements. Depending on the case and the specifics of the legal text, they may integrate limit values, cover the measurement of energy use of LZEVs and incorporate provisions needed to measure (and limit) other environmental impacts (e.g. emissions of local air pollutants).

Table 1. Test procedures used to evaluate fuel economy and direct CO_2 emissions for cars in selected countries

Country/region	Drive cycle
Canada	Federal Test Procedure (FTP), aligned with the CAFE combined driving test cycle in the United States (target year 2025 and earlier).
China	NEDC equivalent up to Phase IV (up to 2020) WLTP for Phase V (target years 2025 and 2030).
European Economic Area	NEDC until 2020, WLTP after that (target year 2030).
India	Modified NEDC (target year 2022).
Japan	JC08 test up to 2020, WLTP after that (target year 2030).
Korea	Aligned with CAFE combined driving test cycle (target year 2030).
Mexico	Aligned with CAFE combined driving test cycle (no net improvements vs. 2015 targets).
Saudi Arabia	Aligned with CAFE combined driving test cycle (target year 2025), allowing NEDC with conversion tables.
United Kingdom	NEDC until 2020, WLTP after that (target year 2030).
United States	CAFE driving test cycle, combining the FTP and highway cycles (target year 2026 and earlier).

Source: https://www.transportpolicy.net, IEA/GFEI (2021), ARAI (2021), ACEA (2021), Ricardo (2020), MOLIT/KOTSA (2015), Jeon et al. (2020) and SASO (n.d.).

Table 2. Test procedures used to evaluate emissions for cars in selected countries

Country/region	Drive cycle
Canada	FTP and Supplemental FTP (SFTP) plus highway for Tier 3 standards, phased in between 2017 and 2025.
China	Test cycles based on NEDC for China 5 (modelled on Euro 5), WLTP for China 6 (implemented as of 2021 and before in selected cities).
European Economic Area	Euro 6 limits in place since 2015-16, test procedure based first on NEDC (until 2017-19), when WLTP was phased in. Between 2017 and 2020 Real-Driving Emissions (RDE) testing phased in.
India	Bharat 6 standards (based on Euro 6) applied from April 2020, test based on the NEDC.
Japan	New long-term emission regulations (Euro 6 equivalent) since 2009-10, testing based on JC08 until 2018-21, with the phase-in of WLTP. RDE will also apply from 2022.
Korea	Petrol vehicles tested based on FTP/SFTP and highway; diesel subject to Euro 6 limits since 2014, first tested with NEDC and since 2018 with WLTP with RDE (the latter is also applicable to petrol).
Mexico	Either Euro 4 (with NEDC-based testing) or Tier 2 Unites States standards (with FTP-based testing).
Saudi Arabia	Euro 2 with NEDC based testing, switch to Euro 5 (and still NEDC) in 2022-23 for petrol and 2024-25 for diesel vehicles, based on NEDC testing.
United Kingdom	Euro 6 limits in place since 2015-16, test procedure based first on NEDC (until 2017-19), when WLTP was phased in. Between 2017 and 2020 Real-Driving Emissions (RDE) testing phased in.
United States	FTP and Supplemental FTP, SFTP and highway for Tier 3 standards, phased in between 2017 and 2025.

Source: https://www.transportpolicy.net, Continental (2019), Delphi (2020), ACEA (2021), ARAI (2021) and Ricardo (2020).

The importance of taking action to cut emissions from passenger and freight vehicles, and in particular passenger cars, is clearly reflected in the political decision that led to the definition and approval of the ASEAN fuel economy roadmap outlined in Box 1.

Despite the differences that still exist, Table 1 and Table 2 indicate that, at a global scale, significant progress has been made towards greater global harmonisation of fuel economy and pollutant emission measurement tests, with two main approaches being widely followed:

- The CAFE driving test cycle, combining the federal test procedure (FTP) and highway cycles. These are most relevant for the North American market (Canada and the United States), as well as Korea and the Middle East for petrol cars.[6]
- The WLTP, currently used in China, the European Union, India, Japan and the United Kingdom. It is also used for the fuel economy testing of diesel cars in other countries (including Korea and Saudi Arabia).[7]

In their latest iteration, these tests systems have also integrated complementary tests not only aiming at assessing environmental impacts in real driving conditions, but also at measuring energy use and emissions for PHEVs, BEVs and FCEVs. In addition, they are not limited to the assessment of these performances as new vehicles, but also consider how they evolve as they continue to be used over their lifetime, integrating in-service conformity and durability tests.

Mapping test procedures to UN regulations

The approaches described in tTable 1 and Table 2 that rely on the NEDC and the WLTP tests are also associated with key regulatory texts, available in the framework of the United Nations' WP.29. These include:

- Global Technical Regulation 15 (GTR 15), which contains provisions regarding the WLTP, without integrating limit values on emissions (UNECE, 2021a).
- UN Regulation 101, which contains provisions for the measurement of fuel economy and direct CO_2 emissions/km, according to the NEDC test (00 and 01 series of amendments).[8]
- UN Regulation 83, which contains provisions for the measurement of the emissions of local pollutants, according to the NEDC test and reflects different levels of stringency in different series of amendments. The most recent can be mapped as follows: Euro 4 in the 05 series of amendments, Euro 5 in the 06 series and Euro 6 in the 07 series (UNECE, 2019).[9]
- UN Regulation 154, which updates UN Regulation 101 (on energy consumption) and UN Regulation 83 (on the emissions of local pollutants), relies on the WLTP and is applicable for Euro 6 tests and limit values.[10]

These documents are also continuously updated in the UN multi-lateral context. For example, while UN Regulation 154 does not include provisions related to real driving emissions (RDE), these will be included in a forthcoming UN Regulation and Global Technical Regulation (UNECE, 2021b).

Data recording and processing capacity: Prerequisites for effective fuel economy policies

Governments that have developed successful policies on fuel economy and the mitigation of emissions did not stop at the choice of an appropriate procedure to measure the performance of vehicles. They also

recorded each measurement and made it available in a database. They also ensured that the database structure was compatible with the information available on vehicle registration statistics. In best practice examples, obligations to make the datasets publicly accessible supplement these provisions.

However, collecting and recording the data is not sufficient. Ensuring that public authorities have the capacity to process these sets of information is crucial to several other policy-making steps, such as, benchmarking the average fuel economy of all newly registered vehicles, developing economic incentives or penalties in a way that allows governments to anticipate the budgetary implications of such a policy, developing fuel economy standards and monitoring progress towards their achievement.

One of the best examples illustrating the importance of the development of the reporting and data processing capacity is in the European Union, where Regulation (EC) No 443/2009, later followed by the Regulation (EU) 2019/631, requires countries in the European Economic Area to record information for each new passenger car and van registered in their territory. Regulation (EU) 2018/956, followed by Regulation (EU) 2019/1242, does the same for heavy-duty vehicles[11].

EU member states and the European Commission then process these data to benchmark the emissions and remain up to date regarding key driving parameters for all new vehicles registered in the European Union. This is essential to enforce other aspects of Regulation (EU) 2019/631 and Regulation (EU) 2019/1242, which set average fuel economy standards for all new light and heavy-duty vehicles entering the European market.

These same measurements carried out each year, along with the data records on vehicle sales and subsequent data processing, allow governments to monitor progress and develop other fuel economy policies. For individual member states, these data are also crucial to developing other fuel economy policies, in particular differentiated taxes on vehicle registration and circulation.

Progress in implementing the ASEAN fuel economy roadmap

Despite the ambition stated in the ASEAN fuel economy roadmap of reducing the average fuel consumption of new light-duty vehicles sold in ASEAN by 26% between 2015 and 2025, along with its related actions, progress in terms of energy use and tailpipe CO_2 emissions per kilometre is just a fraction of that stated in the fuel economy roadmap. This is suggested by considering the stable values of grams per kilometre (g/km) of CO_2 (and therefore also energy use) in Indonesia from 2015-19 (IEA, 2021), the stagnation of fuel economy improvements in Malaysia from 2016 to 2019, despite a 7% decline in 2015-16 (IEA, 2021) and improvements estimated at 4% of the 2015 baseline in Thailand, by 2017 (IEA, 2019).[12]

This assessment is confirmed by a heterogeneous outline of policy developments on fuel economy, pollutant emission control and LZEVs in the different ASEAN Member States, as illustrated in the following sections. These results are also drawn from responses to a survey designed for ASEAN Member States along with additional research.

Fuel economy, CO_2 and pollutant emission mitigation policies

Table 3 summarises the current situation for fuel economy and CO_2 and pollutant emission measures (including regulations, incentives or consumer information instruments) applicable to light-duty vehicles, including cars and vans, which are the focus of the ASEAN fuel economy roadmap.

For policies that directly target fuel economy and CO_2 emissions per kilometre (rather than emissions of local pollutants), the summary available in Table 3 indicates that:

- Indonesia, Malaysia, the Philippines, Singapore and Thailand apply differentiated taxation on vehicles. Thailand uses CO_2-based indicators to define their policies. Indonesia and Singapore a combination of engine size and CO_2/km. The Malaysian scheme is based on engine size. The Philippines uses a differentiation based on vehicle prices, which have a weaker link with fuel economy compared with engine displacement (IEA, 2019).
- Mandatory labelling to provide information to consumers on fuel economy and CO_2/km emissions is in place in Singapore, Thailand and Viet Nam. Voluntary labelling is in place in Malaysia and the Philippines.
- Brunei Darussalam has a stated goal to set up fuel economy standards, as yet not reflected in concrete implementing decisions.
- Cambodia, Myanmar and Lao PDR do not have any fuel economy policy in place.

Table 3 also shows that ASEAN Member States that have developed technical regulations for the measurement of fuel economy and CO_2/km emissions (i.e. Indonesia, Malaysia, Thailand and Singapore) have a measurement approach that is aligned with UN Regulation 101. Viet Nam is also considering this, while no decision has been made in the Philippines, to date. This means that six out of the ten ASEAN Member States have not yet taken a decision on a fundamental prerequisite for effective policy action on fuel economy.

Table 3. Fuel economy and emission regulations and measurement approaches

Country	Fuel economy and CO_2/km measurement and policies	Pollutant emission limits and measurement
Brunei Darussalam	No policy in place, stated goal to set efficiency standards of 17.2 km/L by 2020 and 21.3 km/L by 2025.	Currently Euro 4-compatible fuels, vehicle emissions measured according to UN Regulation 83 in the context of the APMRA.
Cambodia	No policy in place.	Currently Euro 4-compatible fuels, vehicle emissions measured according to UN Regulation 83 in the context of the APMRA. Cambodia is mandating Euro 4/IV nationwide in 2022.
Indonesia	Differentiated application of luxury tax including CO_2/km emissions and fuel efficiency, in addition to engine size, as criteria for determining the tax rate, measurement in line with UN Regulation 101. No fuel economy standards as yet (despite a plan to introduce them).	Euro 4 for petrol and Euro 2 for diesel (until April 2022, and then switching to Euro 4), measured according to UN Regulation 83-05 (Euro 4) and 83-02 (Euro 2). Fuel quality is not yet Euro 4 compliant nationwide.
Lao PDR	No policy in place.	Currently Euro 4-compatible fuels, vehicle emissions measured according to UN Regulation 83 in the context of the AP MRA.
Malaysia	Differentiated vehicle excise tax based on engine size, measurement according to UN Regulation 101. Voluntary labelling also in place, also based on UN Regulation 101.	Euro 4 limits, measurement based on UN Regulation 83-05 (without evaporative and low temperature, optional onboard diagnostics). Fuel compliant with Euro 5.
Myanmar	No policy in place.	Currently Euro 4-compatible fuels, planned Euro 5-compatible in 2021 (petrol) and 2023 (diesel), no policy in place on vehicle standards. Vehicle emissions measured according to UN Regulation 83-05 in the context of the AP MRA.
Philippines	Fuel economy labelling included in the energy efficiency and conservation act, implementing methods for measurement of fuel economy not yet specified. Excise taxes on vehicles are differentiated based on vehicle price, which may bear – for ICEVs – some relation on fuel economy.	Euro 4 limits, measured according to UN Regulation 83-05.
Singapore	Fuel economy labelling and differentiated vehicle tax (bonus-malus) based partly on engine capacity and partly on CO_2/km emissions, in addition to labelling, measurement in line with UN Regulation 101.	Euro 6 limits, measured according to UN Regulation 83-07.
Thailand	Differentiated vehicle excise tax based on CO_2/km emissions. Measurement in line with UN Regulation 101.	Euro 5 limits in 2024, measured according to UN Regulation 83-06 (Euro 5). Euro 6 tentatively set for 2025, measured based on UN Regulation 83-07 (Euro 6).
Viet Nam	Mandatory labelling, no established measurement (self-declaration), regulations being considered (likely with UN Regulation 101 for measurement).	Euro 4 limits (Euro 5 for 2022), measured according to UN Regulation 83-05 (Euro 4) and 83-06 (Euro 5).

Source: Based on information collected from ASEAN Member States; https://www.transportpolicy.net; Velasco (2021); Republic of the Philippines (2019); Congress of the Philippines (2018); ACEA (2021); Shah (2020); Suroyo (2021) Kishimoto (2020); Mahalana and Yang (2021); Schröder et al. (2021); APERC (2017); Department of transport (2019); Thitiratsakul (2020); Thitiratsakul and Kendell (2021); Stratas Advisors (2021); Hirose (2021), and Than (2020).

Regarding pollutant emissions, which contribute indirectly to fuel economy improvements by promoting the market uptake of more fuel-efficient vehicles and LZEVs, Table 3 suggests that the ASEAN policy framework is more homogeneous. Currently, fuel quality standards have been aligned across all ASEAN Member States to enable at least Euro 4 compatible after-treatment systems on vehicles.[13] This followed senior-level consultations developed in the region (CCAC et al., 2018) and anticipated the development of the recent Mutual Recognition Arrangement on Type Approval for Automotive Products (APMRA), aiming at trade facilitation (Box 4) and integrating common requirements on UN Regulation 83 (see Table 3).

Thailand and Singapore are currently the only ASEAN Member States that have enforced more stringent policies on tailpipe emissions of local pollutants, bringing them closer to the limit values currently enforced in Europe (Euro 4 limits were enforced in Europe in 2005, superseded in 2009 by the more stringent Euro 5, then followed by Euro 6 limits since 2014). For Singapore, stringency (both for fuels and vehicles) is in line with Euro 6 requirements. Thailand is also in the process of transition to a level of stringency that will align with Euro 6, but the initial plans to implement this have been delayed (Than, 2020; Praiwan, 2020).

Box 4. Using UN regulatory texts for trade facilitation: The new ASEAN arrangement for automotive products

The ASEAN Mutual Recognition Arrangement on Type Approval for Automotive Products (APMRA), established in 2021, agrees to facilitate trade of new light-duty vehicles (cars, vans) and motorised two and three-wheelers in the ASEAN market by reducing administrative burdens and testing requirements (ASEAN, 2021). To this end, the agreement:

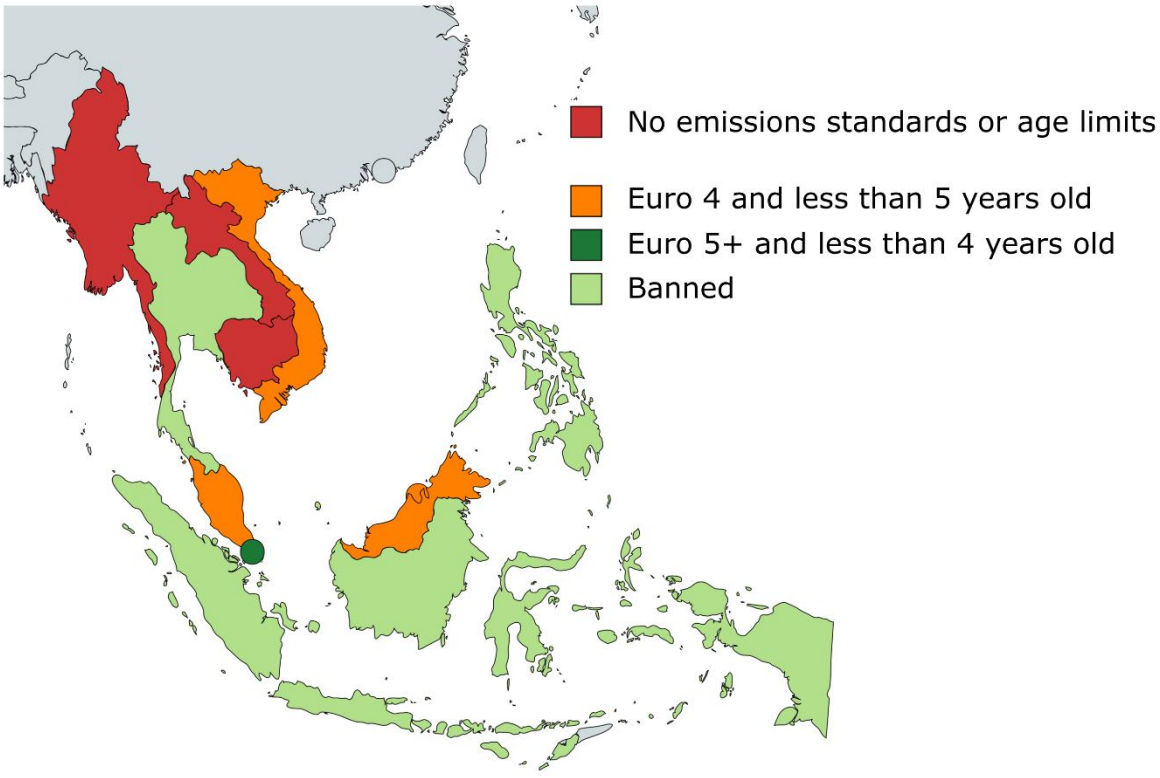
- makes explicit reference to the 1958 Agreement on UN Regulations administered by WP.29
- is centred on the same concept of mutual recognition of type approval underpinning the 1958 agreement.

The APMRA covers a set of 19 UNECE regulations regarding vehicle safety and environmental protection. To regulate the environmental impact of cars and vans (the focus of the ASEAN fuel economy roadmap and this analysis), the APMRA only requires the mutual recognition of type approval certification and conformity assessments of UN Regulation 83 on air pollutant exhaust emissions. Other environmental protection requirements target two-wheelers. Regarding safety, the APMRA includes several provisions related to braking systems, seat belts, head restraints and steering equipment.

The APMRA strengthens capabilities to perform vehicle and component testing and facilitates the development of agreements with other trade partners of ASEAN Member States. However, the APMRA has not yet included regulations on vehicle fuel economy.

Despite the harmonisation of new vehicles entering the ASEAN fleet, facilitated by the APMRA, there are still discrepancies in the way second-hand imports of cars are regulated. According to a recent report by the UNEP, Lao DPR and Myanmar are still not restricting second-hand imports of vehicles that do not comply with the Euro 4 standard. Other countries either ban second-hand imports (this is the case for those with local production) or use regulatory restrictions based on pollutant emission standards and age (Figure 3).

Figure 3. Regulatory frameworks applicable to second-hand imports of cars in ASEAN countries



Source: ITF analysis based on UNEP (2020).

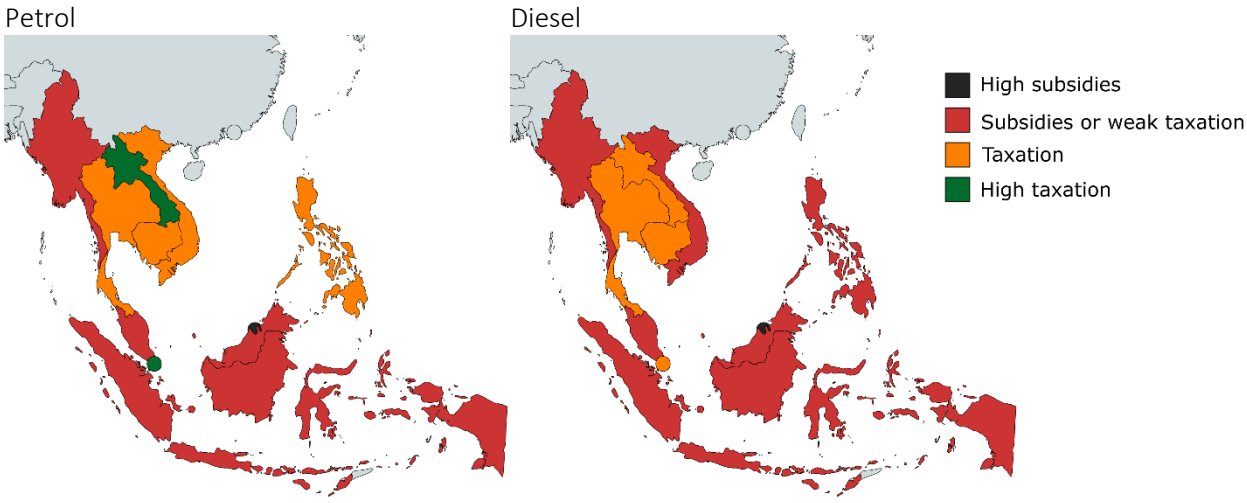
The effect of fuel taxation on fuel economy

Regarding fuel taxation, which is an important determinant of fuel economy due to its impact on the operational costs of vehicles, ASEAN Member States are also adopting approaches that are not uniform.

Figure 4 summarises current taxation regimes in ASEAN Member States, benchmarking them in the context of internationally adopted practices (GIZ, 2020). It shows that some countries (Brunei Darussalam, Indonesia and Malaysia) are still subsidising all petroleum-based fuels, while others (namely Lao PDR and Singapore), apply taxation rates for petrol, which is the fuel with the highest relevance for the car market in the ASEAN region, comparable with those applied in Europe. Figure 4 also shows that Cambodia and Thailand apply taxes on petrol and diesel as does Viet Nam for petrol (but not diesel).

Countries that have subsidies in place tend to be those that have or had a strong oil and gas industry and whose economy is largely reliant on oil and/or gas resources. Countries that apply taxes to petroleum-based fuels are those with higher import dependencies. Other reasons behind fuel subsidies relate to the desire to reduce transport/supply chain costs. Diesel, more frequently used for freight and heavy-duty vehicles, tends to be taxed less than petrol due to potentially negative impacts on the economic competitiveness of the industrial production in the country (given the need to move primary products/feedstocks and distribute finished products).

Figure 4. Fuel taxation regimes applied to road transport fuels in ASEAN Member States



Note: Thresholds defining the different categories of fuel taxation regimes are in line with the analysis developed by GIZ (2020) and earlier versions of this assessment. Retail price of petrol: High subsidies = USD <0.41/litre, Subsidies or weak taxation = USD 0.41-0.87/litre, Taxation = USD 0.88-1.25/litre, High taxation = USD >1.25/litre. Retail price of diesel: High subsidies = USD <0.41/litre, Subsidies = USD 0.41-0.87/litre, Taxation = USD 0.88-1.30/litre, High taxation = USD >1.31/litre.
The category "Subsidies or weak taxation" includes, for diesel, the Philippines and Viet Nam. These countries apply taxes for transport fuels, but they are lower than those applied in the United States. The latter are used as a baseline to define the difference between subsidies and taxes in the GIZ analysis, where all countries applying taxes lower than the United States are deemed to subsidise road transport fuels.

Source: ITF analysis based on GIZ (2020).

Low- and zero-emission vehicle policies

Currently, ASEAN Member States do not adopt a homogeneous approach to the promotion of LZEVs. As with the case of fossil fuel taxation, they can be divided into four distinct groups, as illustrated in Table 4. The criteria defining these groups, though, are different.

Automobile-producing countries in the region (Thailand, Indonesia, and Malaysia) have adopted policies promoting LZEV production. In the case of Indonesia, the availability of nickel reserves helps explain a specific focus on battery electric vehicles (BEVs) and their supply chain (Schröder et al., 2021). Other drivers may include air quality and energy security concerns. Thailand, which has the strongest automotive industry in the ASEAN region, has also adopted a set of electric vehicle (EV) policies including both automobile supply and demand incentives. In the case of Malaysia, policies target a wider spectrum of powertrain and fuel options, not just EVs.

Countries with manufacturing or assembly plants for vehicles at a smaller scale – namely the Philippines and Viet Nam – also support EV production or have seen the emergence of private sector-led initiatives for EV assembly, but with a greater focus on lighter vehicles (two and three-wheelers). The rationale for these policies is grounded on industrial development considerations, as these countries are seeking to secure positions in current internal combustion engine vehicle (ICEV) supply chains and have not yet reached a level and distribution of income per capita that can effectively support demand for the still-costly EVs.

For different reasons, Brunei Darussalam and Singapore enacted LZEV policies with a greater focus on public transport. For Brunei Darussalam this can be explained by the level of endowment in oil or gas resources, although for Singapore, this choice should be seen in the broader context of a long-standing policy-making tradition aiming to favour public transport over private vehicles.

Finally, countries with a lower industrial base, including Cambodia, Lao PDR and Myanmar, have not yet developed any policy support for a transition to low- and zero-emission vehicles.

Table 4. Low- and zero-emission vehicle policy ambition and characteristics in the ASEAN region

Country	Ambition and presence of policies promoting LZEVs	Type of policies in place
Brunei Darussalam	Comparatively low	Reluctant proponent of policy support, primarily targeting public transport and local pollution. National economy based on fossil energy sources.
Cambodia	None	No policy in place.
Indonesia	Comparatively high	Industrial policy to support, defend and expand its position in car manufacturing and emerging supply chains. It includes ambitious goals (EVs at 20% of domestic vehicle sales by 2025) and integrates mechanisms aiming to utilise local nickel deposits for the domestic EV industry. Some policy instruments (e.g. exemption of luxury sales tax) aimed at stimulating demand.
Lao PDR	None	No policy in place.
Malaysia	Comparatively high	Industrial policy to support, defend and expand its vehicle manufacturing industry and emerging supply chains. Allows for negotiated incentives for manufacturers. Policy targeting different technologies (including efficient ICEVs, HEVs, PHEVs and BEVs, as well as biofuels, CNG, LPG): no clear orientation towards EVs. Limited focus on stimulation of domestic demand and deployment of infrastructure needed for access to electricity.
Myanmar	None	No policy in place.
Philippines	Medium	Industrial policy to support and expand its position in car manufacturing and emerging supply chains. Tariff exemption for EV components to encourage local assembly. Focus on lighter vehicles (two and three-wheelers). Limited action aiming to stimulate demand issues and deploy infrastructure needed for access to electricity (only recently addressed with tax incentives for investors).
Singapore	Comparatively low	Broader policy push towards promoting public transport over private transport. Early adopter incentives for EVs have been implemented to offset the cost premium of EVs over ICEVs. A differentiated feebate system is based on environmental performance and not specifically targeted towards EVs.
Thailand	Comparatively high	Industrial policy to support, defend and expand its position in car manufacturing and emerging supply chains. It includes clear conditions for incentives to manufacturers. It also includes incentives to consumers to stimulate local demand. Only country in ASEAN that has developed policy actions for EV grid integration. Approach articulated in three phases, with research and demonstration focus up to 2021, and scale up after that.
Viet Nam	Medium	Private sector initiatives ahead of public policy, and with a focus on two-wheelers. Reduction of the registration fee for battery electric cars to 0% in three years starting from 1 March 2022.

Source: Based on information collected from ASEAN Member States, Schröder et al. (2021), VietnamNet (2022) and Socialist Republic of Vietnam (2022).

Overall, ASEAN Member States apply fuel economy, pollutant emission control and LZEV policies that depend heavily on specific circumstances characterising each member state. The presence of an

automotive industry, the desire to maintain or strengthen it and the endowment with different types of resources (namely oil and nickel ores) are key factors that affect the policy framework.

The presence of a car industry is generally paired with some degree of action taken to promote better fuel economy or the emergence of a market demand for LZEVs, especially in comparison with countries where there is no production of automobiles. However, fuel economy policies remain weaker in comparison with other major global markets, even when the best practices in the region are taken as a benchmark. Notably, regulatory requirements on energy use or tailpipe CO_2/km emissions are not in place in any of the ASEAN countries.

The presence of oil resources or a domestic oil industry tends to be associated with weaker taxation or subsidies on oil products for road transport. This tends to have negative implications for better fuel economy as low petroleum prices lead to lower operational costs, reducing the capacity of energy-efficient technologies[14] to deliver net savings in the total cost of ownership and operation of the vehicles. This, in turn, limits consumer demand for vehicles with better energy efficiency.

Tailpipe emissions of local pollutants (and related fuel quality specifications, especially on sulphur content[15)] are an area where ASEAN Member States have made meaningful progress to a better alignment of their policy framework (although room for improvement in second-hand vehicle imports and the ambition of the policies remains). Currently, all ASEAN Member States have adopted a common procedure to measure emissions of local pollutants from cars, and all apply at least Euro 4 limit values. The development of a trade facilitation agreement, the APMRA, was likely an important driver of this development.

Looking forward, meaningful implementation of the ASEAN fuel economy roadmap – as well as other policies promoting LZEVs – requires a change in pace in policy-making. The following chapter contains several recommendations to this end.

Policy gaps and recommendations

The analysis presented in this report shows that the key requirements for fuel economy policies, in particular the use of transparent and objective measurement procedures for emissions of CO_2/km, are not yet uniformly available in all ASEAN Member States. The phase-out of inefficient fossil fuel subsidies – the subject of a long-lasting series of calls by OECD countries, and recently reaffirmed by the Group of Twenty (G20) – is also not universally adopted in the region (OECD/IEA, 2021).

The heterogeneity of the policy approaches on fuel economy across ASEAN Member States does not help in implementing a common vision and policy framework such as the one outlined in the ASEAN fuel economy roadmap.

While the different socio-economic conditions of ASEAN Member States can explain differences in policy approaches, achieving greater homogeneity is not out of reach. This conclusion emerges by considering the concerted actions taken by all ASEAN Member States on emissions of local pollutants and fuel quality linked to the APMRA and which could clearly be expanded to include the measurement of energy consumption and CO_2 emissions, as well as safety requirements for LZEVs.

In addition to greater homogeneity, progress on energy efficiency and CO_2 emission mitigation to meet the targets of the ASEAN fuel economy roadmap requires greater policy ambition. A lack of ambition would not only hamper the capacity of ASEAN Member States to meet their goals but also fail to bring likely economic benefits to the citizens, since the vast majority of fuel economy improvements come with net savings for users (i.e. lower operational costs of energy-efficient vehicles, often fully offsetting increased purchase costs). In countries having a car industry with export capacity or potential, delaying action on fuel economy policies can also reduce opportunities for industrial development. The following recommendations can help ASEAN Member States to achieve progress towards the fuel economy roadmap.

Strengthen alignment on fuel economy measurement as a key prerequisite for further action

The establishment of a common approach regarding fuel economy and direct CO_2 emission measurement is a crucial enabler of many other fuel economy policy developments. These include labelling, establishing country-specific and regional baselines, monitoring progress on these key indicators over time, applying differentiated taxes on vehicle purchase or circulation, and introducing regulatory developments (fuel economy standards)[16].

Several ASEAN Member States (Indonesia, Malaysia, Singapore and Thailand) use UN Regulation 101 as the technical reference for the measurement of fuel economy and emissions of CO_2/km in vehicles sold in their territory. However, some countries have not yet taken any action in this respect.

UN Regulation 83 is also used in all ASEAN Member States (APMRA agreement) to measure emissions of local pollutants from light-duty vehicles. This shows that regulatory texts developed and maintained in the UN WP.29 framework offer concrete possibilities to progress towards greater harmonisation of fuel economy measurements in the region. The universal adoption of UN regulations should be taken as a model to enable the alignment of what is clearly a key prerequisite for future fuel economy policy developments in the ASEAN region.

Specific steps supporting progress include:

- The universal adoption of UN Regulation 101 as the legal framework allowing the measurement of fuel economy and direct CO_2 emissions per kilometre, including in countries that have not yet defined how fuel economy should be measured or are only using UN Regulation 101 for voluntary reporting purposes.[17]
- Including UN Regulation 101 in the framework of the APMRA, inherently ensuring that it applies to all ASEAN Member States. This could also leverage other features of the agreement regarding how the integration of UN Regulation 101 would be administered in the region.[18]
- Working jointly at a regional level (always in the context of the APMRA) to leapfrog from UN Regulations 83 and 101 to UN Regulation 154 and the upcoming UN Regulation on RDE, as the region moves from Euro 4 pollutant emission and fuel quality limits for light-duty vehicles to Euro 6 (CCAC et al., 2018).

Leapfrogging to UN Regulation 154 (WLTP) along with Euro 6 pollutant emission limits and measurement procedures would ensure that the policy framework remains resilient to upcoming developments in technologies (including the introduction of LZEVs), while also achieving greater global regulatory harmonisation.[19]

Involvement in WP.29 activities is likely to be beneficial for ASEAN Member States, leading to meaningful and resilient progress on these points (Box 5). The alignment with international standards could also strengthen opportunities for innovation-driven industrial development in ASEAN Member States and have positive spillovers for LZEV and other vehicle policy developments in the region.

Box 5. Getting involved in WP.29 activities.

Despite the relevance of technical regulations developed at the United Nations in the context discussed above, only two countries in the ASEAN region are currently involved in WP.29 activities. These are Malaysia, which is a contracting party to the agreements under which UN Regulations and Global Technical Regulations are issued, and Thailand, which is a contracting party to the agreement related to UN Regulations (UNECE, 2021c; UNECE, 2021d). Both have vehicle manufacturing industries in their territory.

Engaging in WP.29 activities can assist ASEAN Member States to:

- Better understand the global development of vehicle regulations, including how and why these are integrated into trade facilitation agreements (such as the APMRA)
- better anticipate changes taking place in vehicle technologies and regulatory frameworks (including but not limited to fuel economy)
- leverage multilaterally developed work on the complex legal texts that underpin global policies on road transport vehicles.

For countries that have (or aim to have) vehicle manufacturing capacity, participation in WP.29 as contracting parties is especially important so as to have a say on global regulatory choices, including those that are steering vehicle manufacturers towards a better alignment with the Sustainable Development Goals (SDGs), making the automotive industry more resilient to global change. [20]

Ensure availability of testing capacity for fuel economy

In addition to the choice of measurement procedures and the development of testing capacity, ASEAN Member States need to build and maintain capacity to perform test procedures. This requires the identification of a regulatory authority and the designation of technical services having the appropriate capacities. This is fully in line with the indications included in the APMRA (Article 7) and is one more signal that the integration of regulation for measuring fuel economy or CO_2 emissions in the framework of the APMRA is a valuable choice.

Additionally, the APMRA already allows for the appointment of technical services located in different countries, if they are designated by a country authority. This is particularly helpful for countries that struggle to develop their own testing facilities. It can serve as an immediate solution for moving forward and can be used as an opportunity to develop co-operative arrangements to help progressively establish domestic testing facilities.

The same provision in the APMRA text could also support leapfrogging to UN Regulation 154 (along with Euro 6 pollutant emission limits), helping manage and overcome differences in the availability of technical expertise across ASEAN Member States.

Build data processing and storage capacity for benchmarking, monitoring and decision making

Strengthening capacity to record and process measurement information at regular intervals is another fundamental requirement in the development of benchmarks for vehicle performance on fuel economy and other environment-related parameters. This capacity needs to be developed either at the member state national administrative level, at the ASEAN level, or both. The European requirements included in Regulation (EU) 2019/631 could serve as a template or inspiration for these benchmarks.

The systematic and regular collection of fuel economy measurement data and other environment-related parameters should also be accompanied by the capacity to track information on the number of vehicles entering the market. Fuel economy measurements along with other key parameters should be collected in a way that is consistent with the level of disaggregation used for the identification of the volume of vehicles entering the market. The system should be able to record information on each vehicle entering the market, tracking them according to criteria that group together vehicle models from the same manufacturer with the same fuel economy or CO_2/km emission rate.[21]

To ensure that the data are reliable, timely and available at regular intervals (annually), ASEAN Member States should clearly designate which authorities should provide and maintain the datasets. Typically, authorities with the capacity to provide correct and complete information could include vehicle manufacturers and importers, or vehicle registries, provided they can track information on fuel economy and other parameters evaluated by technical services. Making the data available transparently to the public is also essential to ensure that their accuracy and credibility are verifiable.

The authorities delegated to collect and process these data would not only have the option to use this for benchmarking purposes but also to monitor progress over time. The same information is also crucial to developing other fuel economy and environmental policies (such as differentiated taxation and regulatory requirements for improvements implemented over time).

Adopt and align policy tools to strengthen ASEAN fuel economy ambition

Better alignment and increased ambition in fuel economy policies are essential to mobilising industry responses to policy actions, as they facilitate the task of automakers and importers to bring better vehicles to the region. This is also crucial for reducing the cost of fuel-saving technologies for consumers.

Key instruments to help ASEAN Member States increase ambition, while also harmonising their fuel economy policy frameworks, include:

- The use of a common labelling scheme. This should cover the parameters to be monitored and exposed in the label (not limited to fuel economy or CO_2), the way they should be measured (e.g. based on UN Regulation 101 or even 154) and possibly the way they should be displayed. Obligations to ensure that the labels are clearly visible to consumers could fall under the responsibility of car dealers. Templates for the development of these labels exist in Europe, Japan, the United States and ASEAN Member States that have already introduced fuel economy labelling.
- The use of a common set of economic incentives or penalties (e.g. differentiated taxation on vehicle registration and/or circulation, based on the environmental performance of vehicles – in particular in terms of grams of CO_2/km). The definition of the legal texts and the enforcement of these measures, as well as compliance, would fall within the mandate of the already existing bodies administering vehicle taxes in each member state. Key challenges may emerge because of different frameworks currently in place. One way to overcome these is through the definition of a roadmap leading to progressive alignments to be achieved over time.
- The development of regulatory requirements on the average fuel economy of vehicles, applicable across the region. In the absence of a delegated regulatory body across ASEAN, the achievement of this goal requires concerted action in each member state. Due to the need to measure fuel economy or CO_2 emissions and monitor progress, this development hinges on the adoption of commonly developed and adopted procedures, not only for measurement but also for reporting and tracking data on a regular basis.

Harmonising these developments across the region requires co-ordinated action by each ASEAN Member State in the development of its legal obligations. This requires the development of a framework to facilitate dialogue and co-ordination, the identification of a set of possible co-ordinated policy choices, the assessment of their potential impacts, identifying best options and the implementation of these in each member state. Such a process could be initiated and developed by the ASEAN Land Transport Working Group or other bodies in the ASEAN and could follow the establishment of a dedicated task force.

The application of all the instruments outlined above is relevant for both new sales and for second-hand imports since the overall fuel consumption of the vehicle fleet depends on both.[22] Second-hand imports also require policy updates to ensure full compliance with the adoption of the Euro 4 pollutant emission standards and a minimum benchmark across all ASEAN Member States. This also applies to updates of these same regulatory limits, with the transition to Euro 6 and beyond.

Overall, accelerating the pace of the adoption of fuel economy policies is essential to meeting the goals outlined in the ASEAN fuel economy roadmap.

Align fuel taxation policies across ASEAN

The same reasons calling for greater harmonisation and ambition on fuel economy policies also call for an alignment of fuel taxation regimes. At a minimum, this should ensure the elimination of fossil fuel subsidies. To be more effective in the promotion of fuel economy improvements, it should also integrate the application of a gradually increasing[23] carbon price.

To work well for economic development, the combined effect of all these measures (including in terms of market transformation, materialising through a transition towards fuel-saving vehicles) should lead to net savings for end-users. Different fuel taxes lead to market heterogeneity, which leads to inconsistent signals for consumers located in different jurisdictions about which technologies are efficient and cost-effective.

A lack of harmonisation on fuel taxes is therefore detrimental to identifying an ASEAN-wide cost-optimal objective for the regulation of fuel economy in the region. Solving this issue while maintaining a harmonised approach will likely require the development of a political compromise. If full harmonisation is not entirely achievable due to the national interest of some member states, the second-best option is to strive for greater convergence, charting a timeline and defining clear milestones for its achievement.

Include low- and zero-emission vehicles in the ASEAN fuel economy roadmap

The analysis developed through this report demonstrates that fuel economy improvements are also strengthened by the increased market penetration of low- and zero-emission vehicles (LZEVs). While these are not currently a major focus of the ASEAN fuel economy roadmap, they should be addressed in the development of future ASEAN energy efficiency (and decarbonisation) policies.

LZEV policies that need to be developed include a common base of technical standards for safety and the evaluation of environmental performance (in the context of the APMRA[24]), tightened standards on tailpipe and other emissions (e.g. from tyre and brake wear), public procurement programmes to mobilise supply and economic incentives or penalties for high fuel consumption vehicles to drive demand. Other measures have a regulatory nature and may include requirements linked to market shares in fuel economy/GHG emissions/km standards, restrictions differentiated on the basis of environmental performances and requirements for road network access (including for low- or zero-emission zones in cities) and requirements for a quicker technological transition in vehicles with high annual mileage.

A second family of policy instruments needs to target the deployment of infrastructure allowing access to new energy vectors (namely, electricity for PHEVs and BEVs, and hydrogen for FCEVs). This also requires dedicated technical standards for safety and environmental performance, economic instruments for infrastructure deployment and regulatory instruments that mandate minimum availability in buildings, cities/urban agglomerations or along major road axes.

LZEV policies should not only focus on direct emissions (including from real-world usage, and therefore reflecting real-world performance) but also cover upstream and downstream impacts (applying a life-cycle approach to sustainable mobility).

Key areas where this is relevant include:

- well-to-tank greenhouse gas emission accounting, along with other quality and sustainability requirements applicable to different energy vectors (especially important for bioenergy and including aspects related to direct and indirect land-use change).

- the carbon footprint, durability and other sustainability requirements that are applicable to vehicle and battery manufacturing, as well as their end-of-life management.
- the interoperability across borders and providers of the energy distribution (charging) infrastructure that LZEV technologies require, ensuring that use and payments can take place smoothly for ASEAN-wide travel by road transport vehicles.

The use of digital technologies is another area requiring policy action, given its importance for a range of further developments in the automotive sector (e.g. the rapid regulatory changes on vehicle connectivity and automation).

As with fuel economy policies, measures aiming to promote the market uptake of LZEVs are also likely to benefit from adequate ambition and regional harmonisation. This is due to the better capacity of measures applicable to a large market (in comparison with a multitude of measures for the sum of smaller markets) to stimulate interest in supplying better vehicles and to attract the investments needed by LZEV production facilities.

Target all motorised vehicles with policies that reduce fuel consumption and CO_2 emissions

Progress in fuel economy measurement is of paramount importance to achieving sustainable mobility. It should apply to both light-duty vehicles (which are the main target of the ASEAN fuel economy roadmap) and other road vehicles such as two and three-wheelers, buses and commercial vehicles (light, medium and heavy).

The recommendations suggested here for light-duty vehicles can also apply to policies aiming to strengthen improvements in other modes, provided that the necessary adjustments are made when it comes to specific details. For example, the UN Regulations for measuring fuel economy and emissions of local pollutants vary across modes. Economic incentives or penalties may also be better allocated to operational expenditures, in the case of heavily used vehicles, such as three-wheelers, taxis, heavy goods vehicles and buses, rather than to capital costs (Noll et al., 2022).

The lessons learnt from the implementation of the ASEAN fuel economy roadmap for light-duty vehicles can provide major insights for other vehicle types and the low-carbon energy vectors that they will require. Expanding the scope of fuel economy policies from light-duty vehicles to other vehicles can also have synergetic impacts leveraged by greater market size. These stem from economies of scale, opportunities to attract investments in the region, ease for manufacturers to develop products (with multiple applications) capable of responding to the policy requirements, and opportunities to leapfrog toward better technologies.

The pace towards zero tailpipe emission vehicles is accelerating quickly, and not only for passenger cars. Ensuring that countries take meaningful action on all vehicle categories and seize new opportunities is in their own interest as global developments clearly show that zero-emission vehicles – especially BEVs – are certainly going to be a growing part of the vehicle technology mix (ITF, 2021b).

Notes

1 The ASEAN fuel economy roadmap was developed with assistance from GIZ and inputs from partners of the Global Fuel Economy Initiative, including the FIA Foundation, the Institute for Transportations Studies of the University of California in Davis, the International Council for Clean Transportation, the International Energy Agency, the International Transport Forum and the United Nations Environment Programme.

2 Low and zero-emission vehicles (LZEVs) include plug-in hybrid vehicles and other vehicles not producing direct tailpipe CO_2 emissions, including fuel cell and battery electric vehicles.

3 The adoption of ambitious public procurement programmes to reduce investment risks in early phases of the technology deployment, when learning and scale effects are not yet strong enough to ensure lower costs. These measures are also instrumental for the early rollout of charging or refuelling infrastructure.

4 These are justified by the fact that high mileage vehicles are the first that should be shifting to technologies that lead to energy (and cost) savings during operation, offsetting higher upfront costs.

5 Sustainable finance thresholds for clean vehicles and energy vectors need to be clearly defined, to ensure that investors influencing the decisions taken by corporations and other entities are aligned with the vision identified for clean vehicle and energy technology deployment, while also ensuring the stewardship of the capital invested, minimising the risk of stranded assets in the presence of climate and environmental policy action.

6 In addition to the information included in Tables 1 and 2, the FTP is also used in Brazil and accepted in other countries in Latin America, along with the NEDC (Continental, 2019; Delphi, 2020).

7 In addition to the information included in Tables 1 and 2, the NEDC (although not yet the WLTP) is also used in Argentina and accepted in other countries in Latin America, along with the FTP (Continental, 2019 and Delphi, 2020).

8 The original (00 series of amendments) text is focused on petrol, diesel, liquefied petroleum gases (LPG) and compressed natural gas (CNG) as fuels, while the second covers additional fuels and vehicle technologies (including hybrids, fuel cell and battery electric vehicles).

9 The switch to WLTP for Euro 6 only took place in the European economic area, and has since been integrated into UN Regulation 154.

10 Regarding UN Regulations, it is important recall that they were instrumental, when initially developed, in facilitating vehicle trade, alongside agreements on the mutual recognition of regulations across countries. Initially they focused on safety, and later they gave more prominence to environmental considerations.

11 For example, the latest version of the regulation related to cars and vans – Regulation (EU) 2019/631 – requires the tracking of the following details: manufacturer's name, type approval number, type, variant, version, make and commercial name, specific emissions of CO_2 (NEDC and WLTP protocols), vehicle mass, wheel base, track width, engine capacity and power, fuel type and mode, eco-innovations and electricity consumption. Similarly, Regulation (EU) 2018/956 requires EU member states and manufacturers to report data related to heavy-duty vehicles. The information collected for all these vehicles is also released publicly by the European Environment Agency (EEA), delegated in the legislation as responsible for the exchange of such data with the competent authorities of the member states and manufacturers, as well as for the management of the final database on behalf of the European Commission. The data are regularly published on the EEA web site (EEA, 2021a; 2021b).

12 Limitations in data availability do not allow for more up to date assessments.

13 Fuel quality limitations (with respect to sulphur content) are an important prerequisite for vehicle regulations for emissions of local pollutants. This is because after-treatment systems for tailpipe emissions of local pollutants cannot work properly in the absence of minimum fuel quality standards, in particular for sulphur content (UN ECE, 2017).

14 Energy efficiency improvements come with a price premium, even if the energy efficiency gap is lower than for other changes in vehicle attributes (IEA/GFEI, 2021).

15 Since sulphur has detrimental effects on the efficacy of catalytic converters, using technologies allowing the abatement of tailpipe emissions requires a parallel reduction of the sulphur content of the fuel to be effective. The United Nations has published recommended levels of sulphur content for different regulations on tailpipe emissions (UNECE, 2017).

16 Some of these instruments – namely baselining – are also essential to monitor progress and evaluate if other policies are effective in bringing the ASEAN forward on its stated goal.

17 This could be achieved with the development of a legal obligation, by each ASEAN Member State, for car dealers to report and expose fuel economy and/or CO_2 and other vehicle properties in labelling schemes aiming to ensure that consumers have access to transparent information on vehicle performances, mandating UN Regulation 101 as the reference for testing fuel economy and CO_2 emissions.

18 This could also allow the Automotive Committee (AAC) – responsible for the implementation of the APMRA – or a dedicated body below it to take the lead on harmonised regulatory transposition effort for the whole ASEAN region, enabling ASEAN countries that have greater capacity to follow the development and update of complex technical regulations to share knowledge and experience with others. This would also ensure that the testing procedure would be equivalent across the region, and that fuel economy and CO_2 emission measurements are comparable.

19 Leapfrogging to UN Regulation 154 would be easier while also transitioning to Euro 6 pollutant emission measurement procedures and limits, since the UN Regulation 154 has been developed in a context where Euro 6 was the framework in place. Applying the UN Global Technical Regulation 15, which details the WLTP test procedures without getting into details on limit values, could also be feasible, but also more challenging in terms of technical expertise, and therefore likely subject to greater barriers.

20 In addition to environmental aspects, including fuel economy and emissions, WP.29 host regulatory developments for other crucial topics, including vehicle safety, connectivity and automation.

21 As mentioned earlier in this analysis, in the case of the European legislation, Regulation (EU) 2019/631 requires tracking the following attributes: manufacturer name, type approval number, type, variant, version, make and commercial name, specific emissions of CO_2 (NEDC and WLTP protocols), masses of the vehicle, wheel base, track width, engine capacity and power, fuel type and mode, eco-innovations and electricity consumption.

22 In cases where fuel economy measurement is not available for used imports, it may be necessary to introduce bans, waiver or require ad hoc testing.

23 The gradual increase is important to manage equity impacts, as an increase in fuel price would have higher impacts for less fuel efficient vehicles that are in the rolling stock.

24 The ASEAN Automotive Federation (AAF) has already proposed UN Regulation 100 (electrical safety, also covering batteries, for 4-wheelers) and UN Regulation 136 (i.e. electrical safety and REESS safety for 2-wheelers) at ASEAN Automotive Product Working Group meetings.

References

ACEA (2021), *The Automotive Regulatory Guide 2021*, https://www.acea.auto/files/ACEA_Regulatory_Guide-2021.pdf.

APERC (2017), "Compendium Of Energy Efficiency Policies in APEC Economies - Brunei Darussalam", https://aperc.or.jp/file/2017/11/17/02_BD.pdf.

ARAI (2021), "Indian emission regulations - Limits, Regulations, Test Cycles, Measurement of Exhaust Emissions and Calculation of Fuel Consumption", https://www.araiindia.com/pdf/Indian_Emission_Regulation_Booklet.pdf.

ASEAN (2021), "ASEAN Mutual Recognition Arrangement On Type Approval For Automotive Products", http://agreement.asean.org/media/download/20210205131820.pdf.

ASEAN (2019), "ASEAN Fuel Economy Roadmap for the Transport Sector 2018-2025: with focus on light-duty vehicles, Jakarta, ASEAN Secretariat", https://asean.org/book/asean-fuel-economy-roadmap-for-the-transport-sector-2018-2025-with-focus-on-light-duty-vehicles (accessed 14 February 2022).

ASEAN (2015), "Kuala Lumpur Transport Strategic Plan (ASEAN Transport Strategic Plan) 2016-2025", ASEAN Secretariat, Jakarta https://asean.org/wp-content/uploads/2021/08/KUALA_LUMPUR_TRANSPORT_STRATEGIC_PLAN_2.pdf

CCAC et al. (2018), "ASEAN Member States Meeting on Soot-Free Transport", Senior Level Consultation on EURO 4/IV Implementation and EURO 6/VI Roadmap, Bangkok, Thailand, https://theicct.org/sites/default/files/Summary%20of%20ASEAN%20Meeting%20on%20Soot-free%20Transport%20(Final)_for%20ICCT%20and%20participants.docx.

Congress of the Philippines (2018), "An act institutionalizing energy efficiency and conservation, enhancing the efficient use of energy, and granting incentives to energy efficiency and conservation projects", Republic Act No. 11285, https://www.doe.gov.ph/sites/default/files/pdf/issuances/ra-11285-enercon-act.pdf.

Continental (2019), "Worldwide Emission Standards and Related Regulations - Passenger Cars/Light and Medium Duty Vehicles", https://www.continental-automotive.com/getattachment/8f2dedad-b510-4672-a005-3156f77d1f85/EMISSIONBOOKLET_2019.pdf.

Craglia, M.A.M. (2020), "The role of technical improvements in decarbonising passenger transport", Doctoral thesis, https://doi.org/10.17863/CAM.59355.

Delphi (2020), *Worldwide emissions standards - Passenger cars and light duty vehicles*, www.delphi.com/sites/default/files/2020-04/DELPHI%20booklet%20emission%20passenger%20cars%202020%20online%20complet.pdf.

Department of transport (2019), "Current Status of Emission and Fuel Efficiency in Lao PDR", Ministry of Public Works and Transport, Lao PDR, https://theicct.org/sites/default/files/Current%20status%20of%20emission%20and%20fuel%20efficiency%20in%20Lao%20PDR.pdf

EEA (2021a), "Monitoring of CO2 emissions from passenger cars – Regulation (EU) 2019/631", European Environment Agency, https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-20 (accessed 14 February 2022).

EEA (2021b), "Monitoring of CO2 emissions from heavy-duty vehicles", European Environment Agency, https://www.eea.europa.eu/data-and-maps/data/co2-emission-hdv (accessed 14 February 2022).

Fontaras, G., N.G. Zacharof and B. Ciuffo (2017), "Fuel consumption and CO2 emissions from passenger cars in Europe - Laboratory versus real-world emissions", *Progress in Energy and Combustion Science*, Vol 60, pp 97-131, https://doi.org/10.1016/j.pecs.2016.12.004

GFEI (2020), *Vehicle Efficiency and Electrification: A Global Status Report*, Global Fuel Economy Initiative, https://www.globalfueleconomy.org/media/791561/gfei-global-status-report-2020.pdf

GIZ (2020), "International Fuel Prices 2018/19", https://sutp.org/publications/international-fuel-prices-report (accessed 14 February 2022).

Greene. D.L, J.M. Greenwald and R.E. Ciez (2020), "U.S. fuel economy and greenhouse gas standards: What have they achieved and what have we learned?", *Energy Policy*, Vol 146, November 2020, 111783, https://doi.org/10.1016/j.enpol.2020.111783.

Greene, D.L. et al. (2017), "How does on-road fuel economy vary with vehicle cumulative mileage and daily use?", *Transportation Research Part D: Transport and Environment*, Vol 55, pp. 142-161, https://doi.org/10.1016/j.trd.2017.06.004.

Hirose, N. (2021), "Malaysia issues standard for energy efficient vehicle certificate", https://enviliance.com/regions/southeast-asia/my/report_2906 (accessed 14 February 2022).

ICCT (2021), "Overview of vehicle fuel efficiency and electrification policies in Indonesia", Briefing, The International Council on Clean Transportation, https://theicct.org/sites/default/files/publications/overview-indonesia-fuel-electrification-policies-jul2021-05.pdf.

IEA (2021), "Explore detailed fuel economy data", Report extract, https://www.iea.org/reports/global-fuel-economy-initiative-2021/explore-data (accessed 14 February 2022).

IEA (2020), "Tracking transport", Tracking report, https://www.iea.org/reports/tracking-transport-2020 (accessed 14 February 2022).

IEA (2019), "Fuel Economy in Major Car Markets: Technology and Policy Drivers 2005-2017", Working Paper 19, https://www.iea.org/reports/fuel-economy-in-major-car-markets (accessed 14 February 2022).

IEA/GFEI (2021), "Vehicle fuel economy in major markets 2005-2019", Working Paper 22, https://www.globalfueleconomy.org/media/792005/wp22-vehicle-fuel-economy-in-major-markets.pdf.

ITF (2022), *ITF Southeast Asia Transport Outlook*, forthcoming, OECD Publishing, Paris.

ITF (2021a), *ITF Transport Outlook 2021*, OECD Publishing, Paris, https://doi.org/10.1787/16826a30-en.

ITF (2021b), "Cleaner Vehicles: Achieving a Resilient Technology Transition", *International Transport Forum Policy Papers*, No. 90, OECD Publishing, Paris, https://www.itf-oecd.org/cleaner-vehicles (accessed 14 February 2022).

Jeon, S. et al. (2020), "An Assessment of Corporate Average Fuel Economy Standards for Passenger Cars in South Korea", *Energies 2020*, Vol 13/17, p. 4533; https://doi.org/10.3390/en13174533.

Jung. J.C. and Sharon, E. (2019), "The Volkswagen emissions scandal and its aftermath", *Global Business and Organizational Excellence*, Vol 38/4, pp. 6-15, https://doi.org/10.1002/joe.21930.

Kishimoto, M. (2020), "Thailand's rush to cut emissions leaves automakers in the dust - Sudden push for strict standards gives R&D little time to keep up", https://asia.nikkei.com/Business/Automobiles/Thailand-s-rush-to-cut-emissions-leaves-automakers-in-the-dust (accessed 14 February 2022).

Mahalana A. and Z. Yiang Z (2021), "Overview of vehicle fuel efficiency and electrification policies in Indonesia", Briefing, The International Council on Clean Transportation, https://theicct.org/publication/overview-of-vehicle-fuel-efficiency-and-electrification-policies-in-indonesia (accessed 14 February 2022).

MOLIT/KOTSA (2015), "The Criteria for the Determination of the Road Load Tolerance in Korea", Presentation, Ministry of Land, Infrastructure and Transport/Korea Transportation Safety Authority, https://wiki.unece.org/download/attachments/36896849/WLTP-16-16e_The%20Criteria%20for%20The%20Determination%20of%20the%20Road%20Load%20Tolerance%20in%20KOREA.pdf

Noll, B. et al. (2022), "Analyzing the competitiveness of low-carbon drive-technologies in road-freight: A total cost of ownership analysis in Europe", *Applied Energy*, Vol 306, Part B, 118079, https://doi.org/10.1016/j.apenergy.2021.118079

OECD (2021), *Economic Outlook for Southeast Asia, China and India 2021: Reallocating Resources for Digitalisation*, OECD Publishing, Paris, https://doi.org/10.1787/711629f8-en.

OECD/IEA (2021), "Update in recent progress in reform of inefficient fossil-fuel subsidies that encourage wasteful consumption 2021", Report prepared for G20, https://www.oecd.org/fossil-fuels/publicationsandfurtherreading/OECD-IEA-G20-Fossil-Fuel-Subsidies-Reform-Update-2021.pdf.

Praiwan, Y. (2020), "Euro 5 upgrade delayed at 6 refineries", Bangkok Post, www.bangkokpost.com/business/1951500/euro-5-upgrade-delayed-at-6-refineries (accessed 14 February 2022).

Republic of the Philippines (2019), "Implementing rules and regulations of Republic Act No. 11285 (energy efficiency and conservation act)", Department of Energy, Department Circular No. DC 2019 - 11 - 0014, https://www.pe2.org/sites/default/files/DOE-DC-2019-11-0014-RA11285-IRR-approved-20191122-OPT.pdf.

Ricardo (2020), "The implementation of emissions standards in India - Bharat Stage VI", https://ricardo.com/emleg/emissions-legislation-database/implementation-emissions-standards-india-bharat-stage-vi (accessed 14 February 2022).

SASO (n.d.), "Saudi Arabia Corporate Average Fuel Economy Standard (Saudi CAFE) for incoming light duty vehicles (2021– 2023)", Saudi Standards, Metrology and Quality Org, https://members.wto.org/crnattachments/2019/TBT/SAU/19_0050_00_e.pdf.

Schröder, M. et al. (eds.) (2021), "Promotion of Electromobility in ASEAN: States, Carmakers, and International Production Networks", ERIA Research Project Report 2021, No. 03, Economic Research Institute for ASEAN and East Asia, https://www.eria.org/uploads/media/Research-Project-Report/2021-03-Promotion-Electromobility-ASEAN/Promotion-of-Electromobility-in-ASEAN.pdf.

Shah, H. (2020), "New Malaysia excise duty regulations introduced for 2020 could see CKD car prices rise by up to 15%", News article, https://paultan.org/2020/01/17/new-malaysia-excise-duty-regulations-introduced-for-2020-could-see-ckd-car-prices-rise-by-up-to-15 (accessed 14 February 2022).

Socialist Republic of Vietnam (2022), "Nghị định số 10/2022/NĐ-CP của Chính phủ: Quy định về lệ phí trước bạ" (Decree No. 10/2022/ND-CP of the Government: Regulations on registration fees), https://vanban.chinhphu.vn/?pageid=27160&docid=205090 (accessed 10 March 2022).

Stratas Advisors (2021), "Seven Countries Move Up in Top 100 Ranking on Diesel Sulfur Limits", https://stratasadvisors.com/Insights/2021/04272021-Top-100-Diesel-Sulfur-Ranking.

Suroyo, G. (2021), "Indonesia reinstates temporary tax break for small-car sales", The Jakarta Post, https://www.thejakartapost.com/news/2021/09/17/indonesia-reinstates-temporary-tax-break-for-small-car-sales.html (accessed 14 February 2022).

Than (2020), "The diesel car camp runs through the dust. Sliding Euro 5 exhaust standard", (**ค่ายรถดีเซลวิ่งฝุ่นตลบ เลื่อนมาตรฐานไอเสียยูโร** 5), https://www.thansettakij.com/content/motor/444399 (accessed 14 February 2022).

Thitiratsakul. R. (2020), "Fossil fuels quality standards", Presentation for APERC Workshop, https://aperc.or.jp/file/2020/12/22/3-2._Fossil+fuels+quality+standards.pdf.

Thitiratsakul R. and J. Kendell (2021), "Harmonizing transportation fuel quality standards to resolve oil trade and environmental issues in APEC", https://iaee2021online.org/download/contribution/fullpaper/259/259_fullpaper_20210531_114309.pdf.

Toh, Eu Jin (2021), "ASEAN Fuel Economy Roadmap", presentation made at the kick-off meeting of the ITF-ASEAN Transport Research Proposal on the Implementation of the ASEAN Fuel Economy Roadmap for the Transport Sector.

TransportPolicy.net (2021), https://www.transportpolicy.net./ (accessed 14 February 2022).

UN (2021), "Secretary-General's statement on the IPCC Working Group 1 Report on the Physical Science Basis of the Sixth Assessment', https://www.un.org/sg/en/content/secretary-generals-statement-the-ipcc-working-group-1-report-the-physical-science-basis-of-the-sixth-assessment (accessed 14 February 2022).

UN DESA (2019a), "South-Eastern Asia", in *World Population Prospects 2019, Volume II_ Demographic Profiles*, pp. 134-137, https://population.un.org/wpp/ (accessed 14 February 2022).

UNECE (2021a), "Global Technical Regulations (GTRs)", https://unece.org/transport/standards/transport/vehicle-regulations-wp29/global-technical-regulations-gtrs (accessed 14 February 2022).

UNECE (2021b), "Informal document GRPE-84-7", https://unece.org/sites/default/files/2021-11/GRPE-84-17e.pdf.

UNECE (2021c), "Agreement concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulation", Economic Commission for Europe, https://unece.org/sites/default/files/2021-02/ECE-TRANS-WP.29-343-Rev.29.pdf.

UNECE (2021d), "Status of the Agreement, of the Global Registry and of the Compendium of Candidates", Economic Commission for Europe, https://unece.org/sites/default/files/2021-11/ECE-TRANS-WP29-1073-Rev31e.pdf.

UNECE (2019), "Proposal for an amendment to Annex 4 to the Consolidated Resolution on the Construction of Vehicles (R.E.3)", https://unece.org/DAM/trans/doc/2019/wp29/ECE-TRANS-WP29-2019-118e.pdf.

UNECE (2017), "Consolidated Resolution on the Construction of Vehicles (R.E.3) - Revision 6", Economic Commission for Europe, https://unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP.29-78r6e.pdf.

UNEP (2020), "Used vehicles and the environment - A global; overview of used light duty vehicles: flow, scale and regulation", United Nations Environment Programme, https://wedocs.unep.org/bitstream/handle/20.500.11822/34175/UVE.pdf.

UNFCCC (2021), "Glasgow Climate Pact", United Nations Framework Convention on Climate Change, https://unfccc.int/sites/default/files/resource/cma2021_L16_adv.pdf.

Velasco M. (2021), "Compliance with PH energy efficiency plan urged", Manila Bulletin, https://mb.com.ph/2021/04/12/compliance-with-ph-energy-efficiency-plan-urged, (accessed 14 February 2022).

VietnamNet (2022), "Three-year free registration for zero emission vehicles", https://vietnamnet.vn/en/sci-tech-environment/three-year-free-registration-for-zero-emission-vehicles-809793.html (accessed 14 February 2022).

WEF (2020), "Future of Consumption in Fast-Growth Consumer Markets : ASEAN", Insight Report, World Economic Forum, https://www.weforum.org/reports/future-of-consumption-in-fast-growth-consumer-markets-asean (accessed 14 February 2022).

World Bank (2021), "Long COVID - East Asia and Pacific Economic Update October 2021, World Bank Group, https://openknowledge.worldbank.org/bitstream/handle/10986/36295/9781464817991.pdf.

International Transport Forum

Implementing the ASEAN Fuel Economy Roadmap

This report explores how ASEAN member states can mitigate the negative impacts of the rapidly growing number of cars on the region's roads. More, increasingly larger vehicles consume more energy, emit more CO_2 and cause more local air pollution. Among the policies to counter these trends and make mobility in the region more sustainable is the ASEAN Fuel Economy Roadmap. This study provides support for implementing the roadmap. It looks specifically at policies for making light-duty vehicles more efficient and less emitting but also provides insights for other motorised road vehicles. The report explores opportunities for aligning policies across ASEAN, considers the role of trade agreements and recommends measures for a transition towards electrification.

International Transport Forum
2 rue André Pascal
F-75775 Paris Cedex 16
+33 (0)1 73 31 25 00
contact@itf-oecd.org
www.itf-oecd.org

OECD

Funded by

FIA FOUNDATION

GLOBAL FUEL ECONOMY INITIATIVE
FOR ZERO CARBON VEHICLES BY 2050

Published: 03/2022 | Photo credit: joyfull/Shutterstock