GLOBAL FUEL ECONOMY INITIATIVE
FOR ZERO CARBON VEHICLES BY 2050

ZERO PATHWAY

SECURING GLOBAL FLEET TRANSFORMATION

GFEI'S ZERO PATHWAY

FIA FOUNDATION · UN environment programme · iea · UCDAVIS INSTITUTE OF TRANSPORTATION STUDIES · icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION · International Transport Forum

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EXECUTIVE SUMMARY

Cutting global emissions by 2050 demands unprecedented action. A transformational approach to decarbonising vehicles is needed - with a dual focus on rapid electrification and ongoing efficiency improvements.

COP26 marks a crucial moment for ramping up ambition and action to achieve net zero. The UN Secretary General has called for sales of internal combustion engine (ICE) vehicles to be phased out in leading manufacturing countries by 2035 and globally by 2040, echoing the targets set out in the Marrakech Partnership's Climate Action Pathway for Transport. However, so far, most focus has been on the leading markets and cars or two wheelers, and more work needs to be done to include heavy vehicles and ensure that low- and middle- income countries are able to achieve this transition just five years later.

GFEI's new ZERO pathway sets out how all countries can meet these targets, by setting out priorities for countries in different situations and contexts to achieve the trajectories needed to reach this global sales phase-out by 2040, in order to decarbonise vehicles by 2050.

GFEI's ZERO pathway builds on over a decade practical support to over 100 countries to develop low-carbon and fuel-efficient vehicle policies. At the heart of this approach is a strong commitment to capacity-building, sharing of experience and supportive interaction. This means:

- The promotion of **electrification** and ongoing improvements in **fuel efficiency** of ICE vehicles must not be seen as competing, but rather as complementary measures.

- Both require the **continued use of a range of policy instruments**, including the **removal of fossil fuel subsidies**, the use of **fossil fuel taxes and carbon pricing** mechanisms, **tightened regulations for tailpipe CO_2 emissions, and the carbon content of fuels,** and **economic incentives for energy efficient vehicles**.

- **The transition to Zero Emission Vehicles (ZEVs) requires additional policy tools**, including the development of **technical standards, public procurement** programmes, **power sector reforms** allowing optimisation of EVs and renewable or low-carbon electricity, **economic measures and regulatory requirements** stimulating **demand for electric vehicles (EVs) in the market** and the deployment of the **charging infrastructure** that they need.

- **ZEVs also require policies** aiming to ensure that the **materials required for batteries and renewable electricity are available and sustainably sourced and handled at the end of their useful life**, that potential **shortfalls in government revenues from a shift away from fossil energy can be managed,** and that the implications of this technology transition (along with the digital one) on **jobs can result in net benefits for the workforce**.

- **Mobilising investments** towards clean vehicles and clean energy will also be essential to achieve the transition successfully. Regulations clarifying which activities are aligned with **sustainable finance requirements** will have a crucial importance to achieve this, for developed and emerging economies.

Given the complexity of this set of policies, achieving a truly global transition will require that governments – especially in emerging economies – are effectively supported by significant **capacity-building** activities, enabling them to leapfrog to ZEVs at affordable costs and avoid becoming the dumping ground for used combustion engine vehicles, with greater exposure to increased volatility of fossil fuel prices.

Finally, and regardless of progress with electrification, the only true path towards achieving the Paris targets must also include changes in the types of vehicles used, including more **non-motorised mobility – such as walking and cycling, and shared mobility that is effectively integrated with high-capacity public transport services**.

TRAJECTORIES FOR DIFFERENT MARKET TYPES

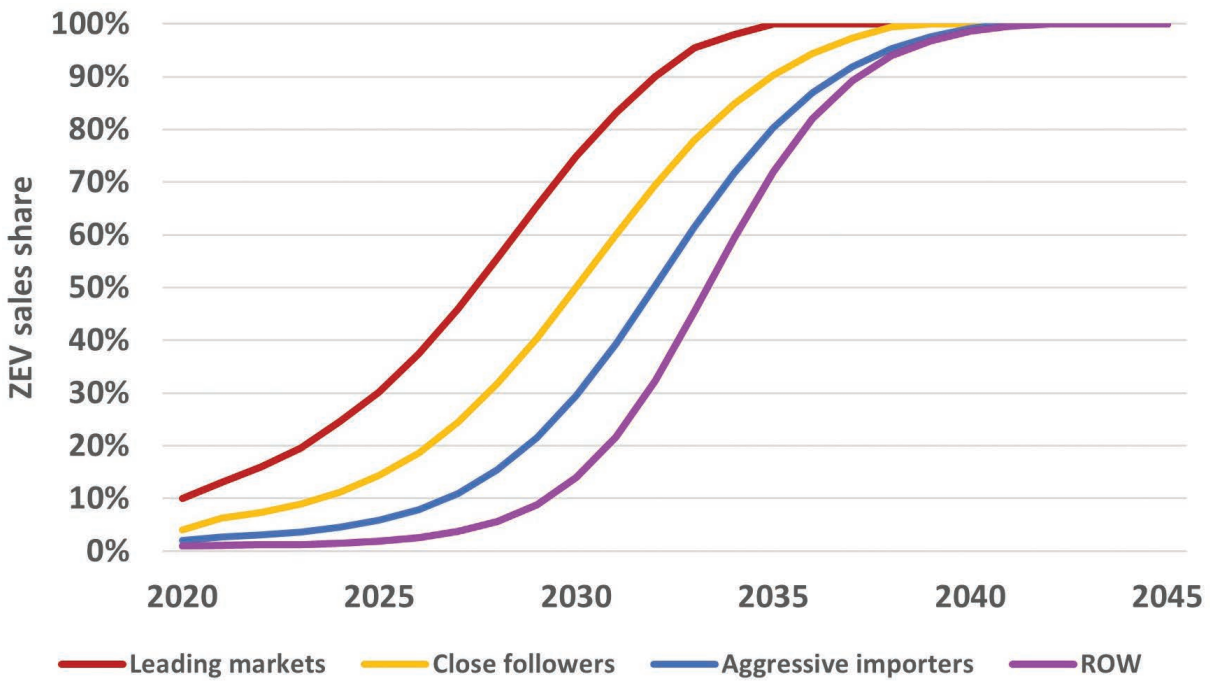
GFEI's ZERO pathway maps the sales increases needed in different market types to achieve rapid reductions, recognising that not all countries are in the same position as the leading markets that are already seeing rapid increases in EVs. **Achieving 100% sales share of EVs in all markets globally by 2040 could lead to a 77% CO_2 reduction in 2050 relative to a business-as-usual case (and 81% compared to today).** This would set a trajectory to reach zero as stock turnover completes and global electricity production nears carbon neutrality.

As shown in the figure below, we create trajectories for each of four types of country and vehicle market, that have their own pathways and are in very different places in 2030, but all reach the 100% EV sales target by 2040.

This report offers detailed guidance on key policy priorities for these four illustrative 'market types':

- **Leading markets** that have already set strong targets and made considerable progress in adopting EVs. These seem likely to include parts of Europe (such as Nordic and other northern European countries), and parts of other countries (such as California and Quebec).
- **Close followers** that tend to be major vehicle manufacturing countries that have either set strong targets or set policies that imply such strong targets.
- **Aggressive Importers.** These are non-manufacturing, primarily importing countries with pro-fuel efficient and/or pro EV policies for example through pricing, economic incentives and/or regulatory requirements.
- **Rest of the world.** These include remaining countries, typically importers like the third group, but without the pro-active policy action on energy efficiency and low-carbon vehicles.

Technology curves for light-duty electric vehicles by market type



Source: UC Davis / ITF analysis for this paper

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It explains what interventions are important, the current state of play, and how actions may vary across different markets. It concludes by considering what are the priorities areas for future action.

The seven policy areas are:

1. Technical standards and regulations
2. Clear milestones
3. Efficient levels of energy taxes and carbon pricing
4. Procurement policies
5. Economic Incentives
6. Regulatory limits
7. Green investment frameworks.

It also sets out three emerging policy challenges:

8. Resilient and sustainable supply chains
9. Taxation reform
10. Workforce support

WHY RADICAL ACTION IS NEEDED

Despite technological improvements, the average fuel consumption of new light-duty vehicles has decreased very slowly at only 1.1% per year from 2015-2019. This is nowhere near fast enough to reach the GFEI targets of doubling vehicle fuel economy by 2030, nor any other climate target. Increasing vehicle size and power has eroded as much as 40% of the fuel consumption improvements that would otherwise have occurred thanks to technical advances in vehicles and engines.

Electric vehicles have unparalleled energy efficiency and the lowest life-cycle emissions among all powertrains available. This should also be accompanied by an expansion of low carbon electricity; the potential CO_2 benefits of EVs are greater in scenarios where the power generation system shifts towards low-carbon energy the fastest.

THE PROMISE OF ZERO

If the world can rally around this ZERO Pathway approach, then a net-zero road transportation system will be in reach by 2050. It will also be critical to push toward slower growth in private vehicle travel, and promotion of the most efficient modes such as buses, rail, and active travel (cycling and walking). These modes are also critical for cities to be safe, sustainable, and liveable.

1 THE GLOBAL CONTEXT

Road transport is responsible for nearly three-quarters of transport greenhouse gas emissions, with passenger vehicles responsible for more than 60% of road emissions. With the publication of Climate Change 2021: The Physical Science Basis (the Working Group 1 contribution to the IPCC's Sixth Assessment Report), it is more clear than ever that very strong action is urgently needed to decarbonize transportation rapidly, reaching a near-zero carbon system internationally by 2050.

The Global Fuel Economy Initiative (GFEI) is a partnership of six world-leading organisations - The International Transport Forum (ITF), the International Energy Agency (IEA), the UN Environment Programme (UNEP), UC Davis, the International Council on Clean Transportation (ICCT), and FIA Foundation.

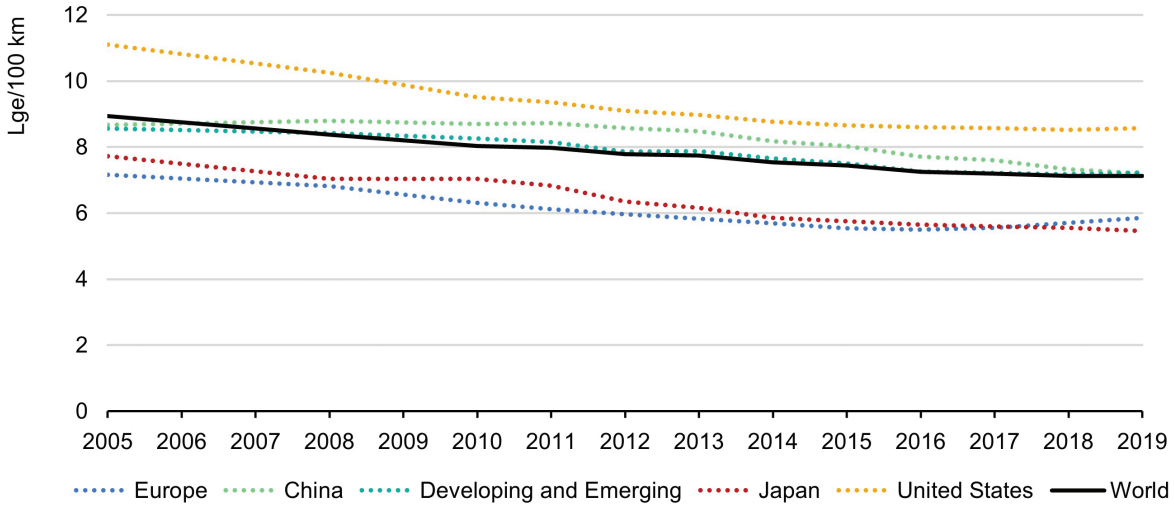
GFEI's initial goal for 2030 was to double light-duty vehicle fuel economy compared with 2005 levels. However, it is clear that to achieve the Paris target of limiting global temperature rises to 1.5 degrees, significant reductions will be needed from all transport modes and GFEI has also identified targets for decarbonising heavy-duty vehicles (HDVs), buses and motorcycles as well as action to support sustainable mobility through walking, cycling, shared mobility and public transport.

VEHICLE EFFICIENCY

As GFEI analysis has shown (Figure 1), The average rated fuel consumption of new light-duty vehicles has decreased very slowly at only 1.1% per year from 2015-2019. This is nowhere near fast enough to reach the 2030 GFEI targets of doubling vehicle fuel economy, nor any other climate target. There needs to be a fundamental shift in the current trajectory.

Global light-duty vehicle sales in 2019 totalled 90 million, a 7% drop compared to the historic peak in 2017. The three major car markets, China, the USA and the European Union accounted for 60% of all sales. The average rated fuel consumption of new LDVs in 2019 was 7.2 litres of gasoline equivalent per 100 kilometres (lge/100 km), a mere 0.9% decrease since 2017, far lower than the 2.6% annual average reduction achieved from 2010-2015.

FIGURE 1: Rated fuel economy of new vehicles 2005-2019



Source: IEA (2021) Fuel Economy in major car markets 2005-2019, GFEI Working Paper 22

Globally, improvements in average new fuel consumption and tailpipe CO_2 emissions have stalled, not accelerated, between 2017 and 2019. Over those three years, average rated fuel consumption rose in Europe, as the CO_2 emission regulation did not require any further improvement until 2020, when emissions from new vehicles declined by more than 10% year on year. In the USA, the average fuel consumption of new LDV remained unchanged between 2017 and 2019, following a relaxation of fuel economy standards in that period. In contrast, average fuel consumption declined in China, driven by fuel economy standards, and in emerging markets and developing economies.

Global average rated CO_2 emissions in 2019 were 167 grams CO_2 per km (gCO_2/km), a 1.6% decrease since 2017. Market penetration of electric LDVs explains the fact that the reduction in rated CO_2 emissions was greater than the reduction in rated fuel economy.

These improvements are significantly lower than the 2.8% yearly fuel economy improvements that would have been needed to halve the fuel consumption of new LDV sales from 2005 to 2030. Given slow progress to date, achieving this 2030 GFEI target from current levels will require average rated fuel consumption of new LDV sales to decrease by 4.3% per year on average from 2019 to 2030: a near tripling of the average annual pace of improvement since 2005 to date. Such a step change in fuel consumption trends can only be brought about by enhanced policies that lead to higher market shares of efficient electric powertrains as well as a globally widespread adoption of state-of-the-art internal combustion engine efficiency technology.

GFEI TARGETS

Passenger light-duty vehicle targets
Double global fuel economy of new vehicles by 2030, reduce CO_2 emissions by **90%** by 2050

2030 **50%**

2050 CO_2 **90%**

Heavy-duty vehicle targets
Improve new vehicle fuel consumption **35%** by 2035 - CO_2 reduction target of **70%** by 2050

2035 **35%**

2050 CO_2 **70%**

Transit bus targets
Improve fuel economy to reduce CO_2 emissions by **65%** by 2035 and **95%** by 2050

2035 CO_2 **65%**

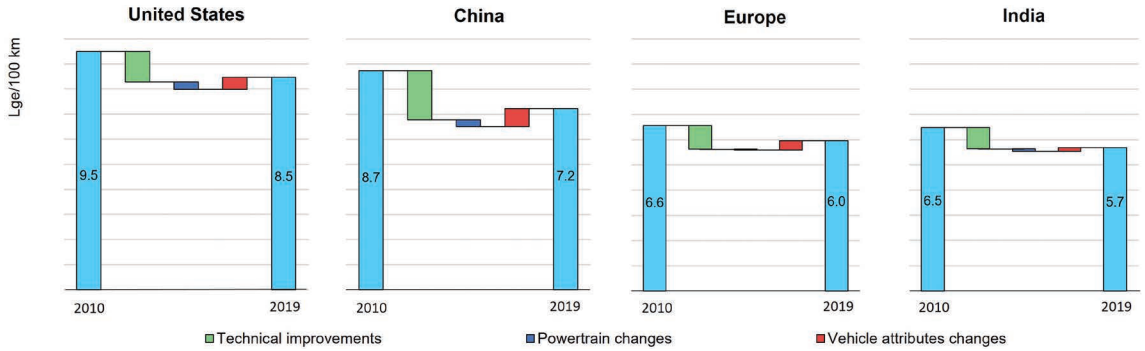
2050 CO_2 **95%**

Two & three wheel vehicle targets
Improve fuel economy to reduce CO_2 emissions by **80%** by 2035 and **95%** by 2050

2035 CO_2 **80%**

2050 CO_2 **95%**

FIGURE 2: Decomposition of fuel consumption trends, 2010-2019



Source: IEA analysis based on IHS Markit database

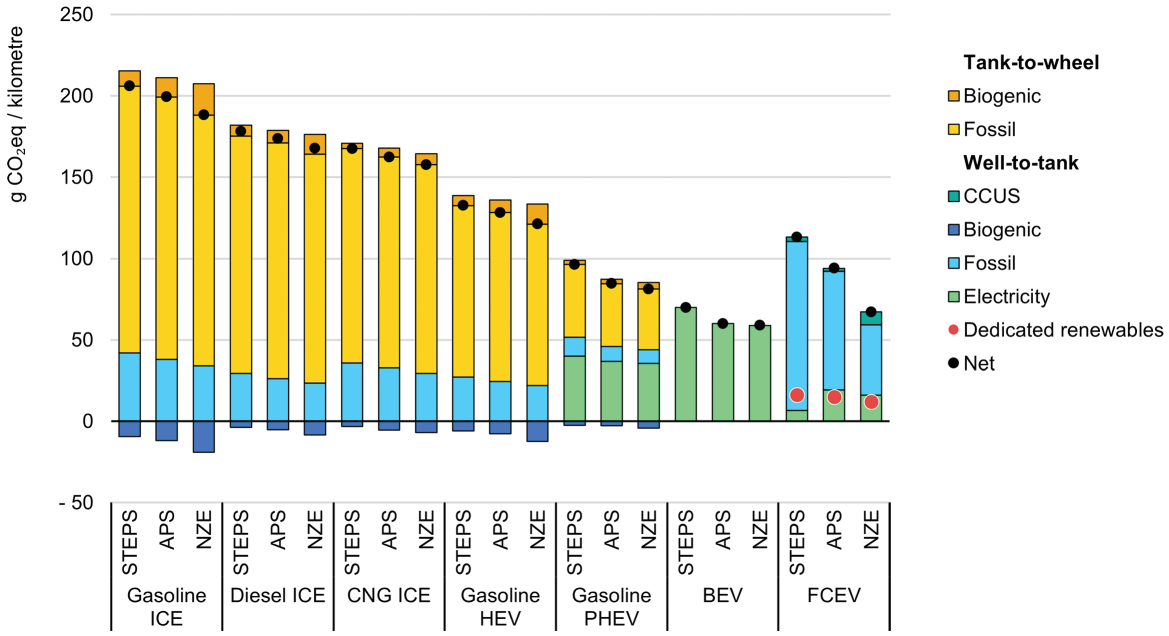
Vehicles are getting larger and more powerful, eroding progress on fuel economy. But even if they weren't, we still wouldn't be on track to achieving the 2030 GFEI fuel economy target. The pace of adoption of efficient powertrains has not been fast enough.

Between 2010 and 2019, according to sales-weighted averages, new light-duty vehicles became 6.2% heavier, 20% more powerful and had a 7% larger footprint, with the most rapid increases having occurred in China (Figure 2). A key driver of this trend has been the shift from cars (sedans) to SUVs and light trucks. SUVs are larger and heavier than conventional cars and therefore require more power and consume on average 15% more fuel than the average vehicle. While in 2010 SUVs accounted for 20% of the global LDV market, by 2019, 44% of new sales were SUVs. Even in markets with high SUVs shares such as the USA, the sales share of SUVs continues to grow. In Japan, the trend toward larger and heavier vehicles has been far more muted than in most other developed countries, in part due to long standing policies promoting Kei-cars. This, together with high shares of HEVs among new car sales (20% in 2019), have driven continuing improvements in rated fuel economy of new LDV sales in Japan (Figure 1).

Increasing vehicle size and power has eroded as much as 40% of the fuel consumption improvements that would otherwise have occurred thanks to technical advances in vehicles and engines. Yet, even if vehicles had not grown in size and power, the global fleet would likely still not be on track to meeting the GFEI targets, as technical improvements on conventional powertrains are not sufficient and are slowing down. This lack of momentum must be addressed at the same time as EVs are being promoted.

The latest GFEI Working Paper 22 confirms that electric vehicles (EVs) have the lowest well-to-wheel emissions among all powertrains available, although their CO_2 benefits are greater in scenarios where the power generation system shifts towards renewables the fastest (Figure 3).

FIGURE 3: Global average well to wheel emissions by powertrain type (2019)



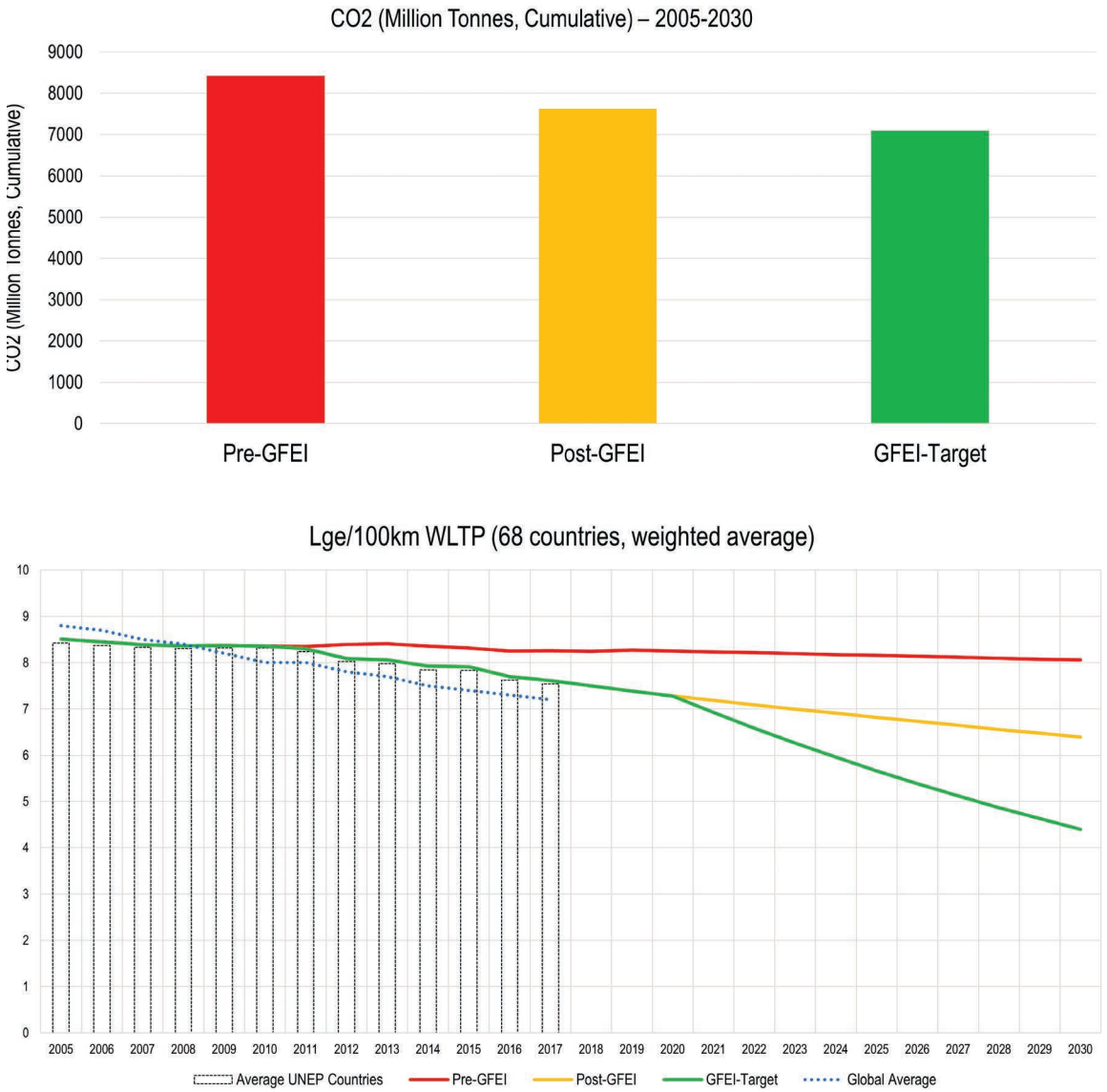
Source: IEA (2021) Fuel Economy in major car markets 2005-2019, GFEI Working Paper 22

BOX 1:

POTENTIAL CARBON GAINS FROM THE GFEI'S TARGET FOR LIGHT-DUTY VEHICLES

UNEP estimate that in the 68 countries where they have provided support as part of GFEI, 209MT of CO_2 have already been saved (2005-2020) because of vehicle fuel economy improvements. Over the next decade to 2030 this will increase by a further 584 MT of CO_2, or 1116MT if GFEI's goal of doubling vehicle fuel efficiency by 2030 is achieved. (See Figure 4).

FIGURE 4: Cumulative CO_2 savings to 2030 from hitting GFEI targets



Source: UNEP analysis for GFEI

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ZEV TARGETS AND ICE PHASEOUT

Announcements regarding EV and other low-carbon vehicle targets and policies are being made almost daily around the world. For example in August the US announced a target of 50% sales share of light-duty electric vehicles by 2030. California had already set a target of 100% zero-emission vehicle sales by 2035.

The UN Secretary General has called for a full phaseout of ICE road vehicles by 2040 around the world. Further to this, the UNFCCC released its Climate Action Pathway for transport as part of the lead-up to the COP26 in Glasgow in November 2021. This includes a call for reaching very ambitious targets for electrifying various modes across road transport:

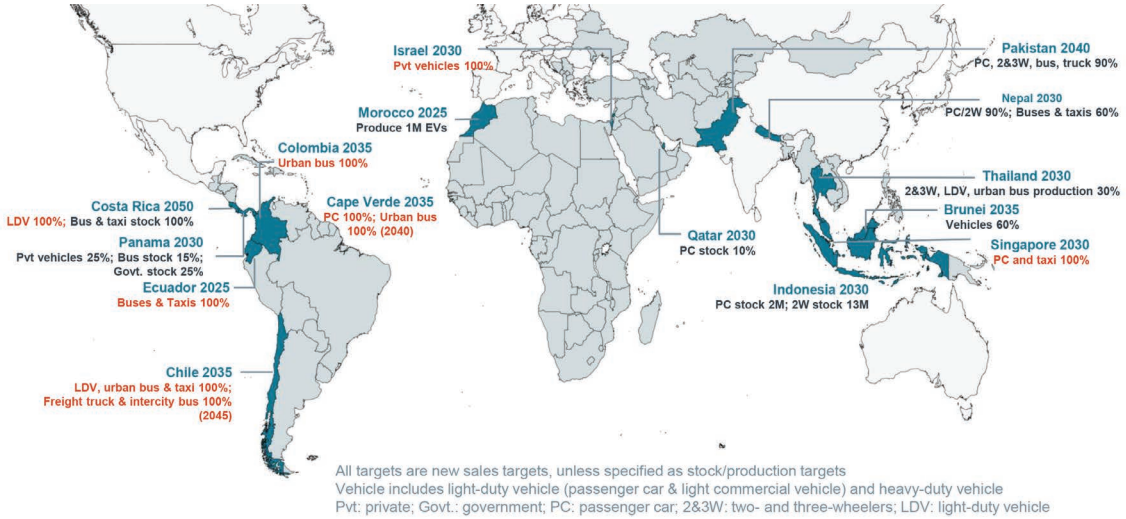
- For the car segment, "leading markets" should reach a 75% electric vehicle (EV) market share by 2030 and commit to a target of 100% by 2035. The rest of the world should reach 100% sales by 2040.
- For buses, leading markets should reach 100% market share by 2030.

- For "heavy duty vehicles" (presumably all trucks), leading markets should reach 40% market share in 2030 and 100% by 2040 in leading markets.

These are very ambitious targets - particularly for 2030 - and are most achievable for leading markets. Other countries and regions have set their own ambitious targets (Figure 5), which may be slightly lagged behind these, but still with an overall target to eliminate CO_2 emissions from road transportation by 2050. This means achieving 100% electric vehicle sales across all modes by 2040 at the very latest.

Ambitious targets are needed to accelerate action - particularly where these are backed up by ZEV mandates or ICE sales bans. In the analysis that follows we explore how countries might aim to reach an overall global target of ZEV sales by 2040.

FIGURE 5: Country plans for fleet electrification



Source: ICCT

ANALYSIS

To inform this process, we consider what policy frameworks still need to be developed in these these "leading countries" and, and sub-divide the remaining countries into "close followers" "aggressive importers", and "the rest of the world" according to features such as whether they are manufacturers and whether they have already begun to set standards and targets for other aspects of fleet transformation. This is important in order to better understand their position and perspective in relation to these targets and the transition to EVs more generally.

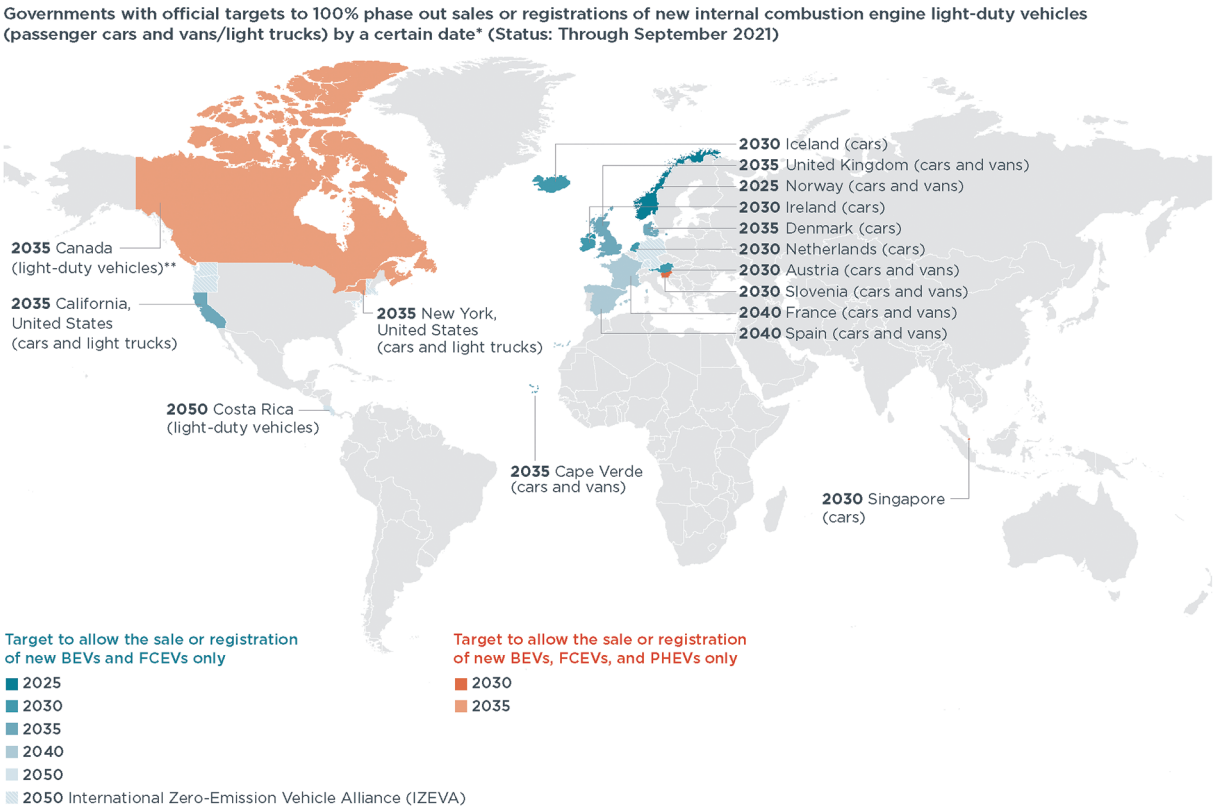
These new targets would scale-up existing announcements to phase out internal combustion engine (ICE) vehicles, which have largely been set by leading vehicle manufacturer economies (Figure 6).

For all regions and all road vehicle types, we target a near 100% ZEV sales share worldwide by 2040. The path to get there differs as follows across the four country groups:

1. **Leading markets** that have already set strong targets and made considerable progress in adopting EVs. These seem likely to include parts of Europe (such as Nordic and other northern European countries), and parts of other countries (such as California and Quebec). These are in the best position to hit the Climate Action Pathway targets described above by 2030.

2. **Close followers** that tend to be major vehicle manufacturing countries that have either set strong targets or set policies that imply such strong targets. This group may include most of the rest of Europe, along with Canada, the United States, China and Japan.

FIGURE 6: Governments with targets to phase out ICE vehicles by a certain date



* Includes countries, states, and provinces that have set targets to only allow the sale or registration of new battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs). Countries such as Japan with pledges that include hybrid electric vehicles (HEVs) and mild hybrid electric vehicles (MHEVs) are excluded as these vehicles are non plug-in hybrids.
** The Canadian province of British Columbia has set its 2040 target into binding regulation; the Canadian province of Québec has also set a target for 2035.

Source: ICCT

3. **Aggressive Importers.** These are non-manufacturing, primarily importing countries with pro-fuel efficient and/or pro EV policies for example through pricing, economic incentives and/or regulatory requirements. These would tend to include most of the rest of Europe and Asia, and much of Latin America.

4. **Rest of the world.** These include remaining countries, typically importers like the third group, but without the pro-active policy action on energy efficiency and low-carbon vehicles. Currently, this would tend to include the Middle East and Africa.

While this grouping structures our analysis, it is clear that there could be alternative groupings and many cases where specific countries fall in-between categories. For example, various Asian, Latin American, and small island developing states (SIDS) may fall in either the third or fourth category, and we don't attempt to place each country in its "correct" grouping here. Further, many of them may soon implement ambitious policies that move them up, even bringing them ahead of markets in the second group (e.g. Sri Lanka) or eventually even in line with the first category.

Cutting emissions from transport will require global action, both in the most developed markets, accelerating the transition to electric vehicles in middle and low-income countries as rapidly as possible, Cutting emissions from transport will require global action, both in the most developed markets, accelerating the transition to electric vehicles in middle and low-income countries as rapidly as possible, but also ensuring that the efficiency of existing internal combustion engine vehicles are is maximised.

EV TARGET PATHWAYS BY GROUP AND VEHICLE TYPE

Taking into account the targets set in the Climate Action Pathway report, which apply mainly to the leading countries, and adding in targets for our 3 other country groups, we present potential targets by key year (2030-2045) by group and for each of the 4 major road transportation modes (LDVs, trucks, buses and 2-3 wheelers). These are designed to hit UN targets and reflect other targets and trends that are in place, with an important assumption that importing countries and "rest of world" may start slower but eventually catch up with the leading countries and close followers. This catching up is a critical part of reaching a near 100% EV sales share by 2040 and thus a near-100% EV stock share by 2050 (and thus near-zero emissions systems).

We present the EV sales scenarios below by vehicle type.

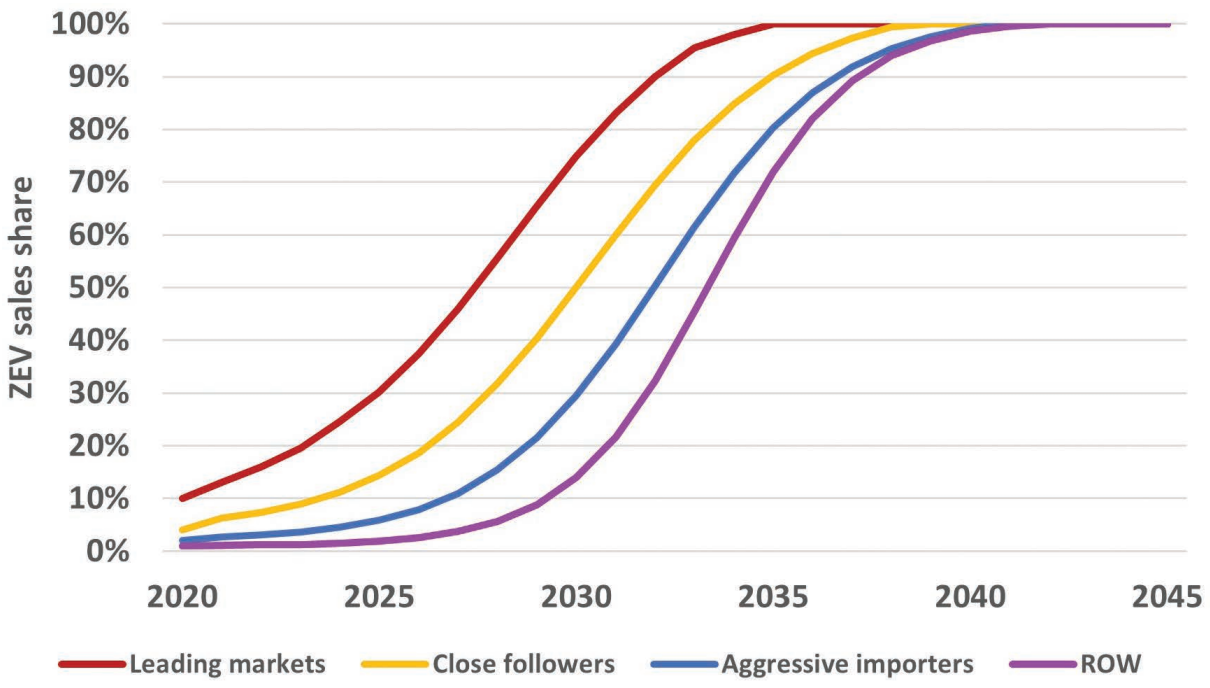
Light-duty vehicles

For LDVs, we follow the Climate Action Pathway target of 75% sales share by 2030 in the leading countries and 100% by 2035. EV technology adoption by group is shown for key years in Table 1 and illustrated as market penetration (sales share) curves in Figure 7.

TABLE 1: Electric light-duty sales shares by country group and year

	2020	2030	2035	2040	2045
Leading markets	10%	75%	100%	100%	100%
Close followers	4%	50%	90%	100%	100%
Aggressive importers	2%	30%	80%	99%	100%
ROW	1%	14%	72%	99%	100%

FIGURE 7: Technology curves for light-duty electric vehicles by market type



Source: UC Davis / ITF analysis for this paper

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One key observation is that in 2030, leading markets achieve a 75% EV market share while close followers are at 50%, aggressive importers are at 30% and ROW is at 10% - a huge range. But by 2040 all of the regions have reached close to 100% shares. The later start by the other groups is offset by faster increases after 2030.

Based on our stock turnover modelling, the results of all of these market penetration curves is about a 90% EV share of global total LDV stock by 2050. Coupled with deep decarbonization of the electricity sector, this scenario achieves the needed targets for a near-zero emissions system.

The decline in LDV CO_2 emissions is shown in Figure 8 in the "Rapid Scenario". It achieves about a 77% CO_2 reduction in 2050 relative to a business-as-usual case (and 81% compared to today), and has a trajectory to reach zero as stock turnover completes and global electricity production nears carbon neutrality. Faster decarbonization of electricity worldwide would speed this CO_2 reduction as EVs become dominant in the fleet.

Next we briefly cover the similar types of market uptakes considered feasible for trucks, buses, and 2 wheelers below. These would provide similar CO_2 reductions for their modes as seen for LDVs.

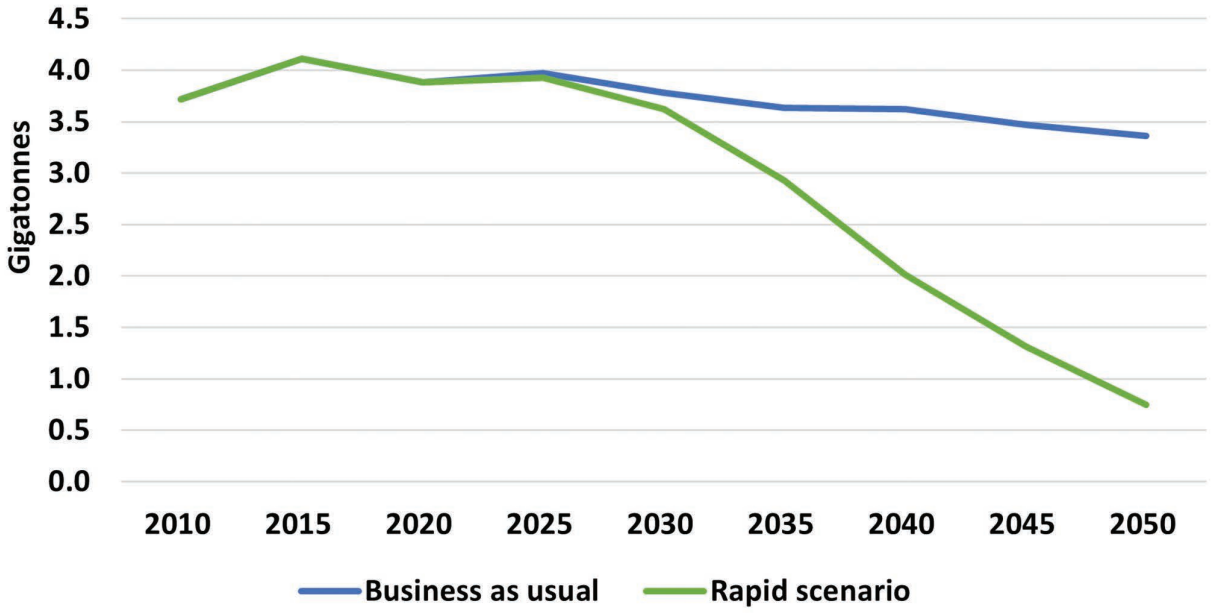
Trucks

For trucks (light commercial, medium and heavy duty vehicles except buses), we follow the UN target of 40% sales share in leading economies by 2030, and lag the other regions accordingly, but still with a focus on achieving a near 100% EV sales share by 2040 (high 90s). This scenario reaches about 94% of truck stocks as EV globally by 2050. California at this time appears to be the main leading market, but the US, EU, and/or China may move into this group in the coming few years (Table 2).

TABLE 2: Truck EV sales shares by country group and year

	2020	2030	2035	2040	2045
Leading markets	1%	39%	86%	99%	100%
Close followers	1%	26%	81%	99%	100%
Aggressive importers	0%	14%	77%	99%	100%
ROW	0%	6%	67%	99%	100%

FIGURE 8: Well to wheel CO_2 emissions by scenario



Source: UC Davis / ITF analysis for this paper

Buses

For buses (mainly considering urban transit buses), the rates of uptake are growing rapidly and there is reason to believe that a transition to electric vehicles can occur relatively rapidly around the world. Clearly China is the leading market and has the best chance to transition to 100% electric sales rapidly. California has a target of 100% EV bus sales share by 2030, which appears achievable. The US, EU and Japan are close followers and should be able to transition to 100% by 2035. Other countries follow accordingly, with all countries in the world reaching at least a 50% market share by 2030 and over 90% by 2035 (Table 3).

TABLE 3: Urban bus EV sales share by country group and year

	2020	2030	2035	2040	2045
Leading markets	30%	100%	100%	100%	100%
Close followers	10%	75%	100%	100%	100%
Aggressive importers	59%	68%	96%	100%	100%
ROW	0%	50%	92%	99%	100%

Motorized 2-3 wheelers

For motorized 2-3 wheelers, we assume a very rapid transition, since China's transition is already nearly complete (and we consider China as the main leading market here). Close followers include India and Europe. All countries should be able to achieve a 100% electric sales share of 2-3 wheelers by 2035 (Table 4). For all of these vehicle types and different country types, the pathways are very aggressive and will be very challenging to achieve. But they should be feasible with strong policies.

The next section of the paper discusses policies and strategies necessary for each country group to move onto the pathways shown here. It also identifies how GFEI's Zero Pathway will build on the work which GFEI is already undertaking in over 100 countries, to support this transition.

TABLE 4: 2-3 wheeler EV sales share by country group and year

	2020	2030	2035	2040	2045
Leading markets	75%	100%	100%	100%	100%
Close followers	15%	90%	100%	100%	100%
Aggressive importers	5%	75%	100%	100%	100%
ROW	0%	50%	100%	100%	100%

2 SUPPORTING THE SCALE UP OF ZERO-EMISSION VEHICLES

Policy action has been crucial to support the deployment of EVs. This was most effective in the leading markets, and to a lesser degree also in close followers and aggressive importers. Most policy focus to date has been on light-duty vehicle passenger mobility. Such policies include a broad range of actions, from technical definitions for vehicle and component characteristics to programs to influence choices made by investors, the automotive industry and vehicle buyers. Policy frameworks to stimulate market growth and support the ZEV transition will be vital in achieving the ambitious targets outlined in the UN Climate Action Pathway. This is not only the case for leading markets, but also for all regions, although the timing, relative priorities and vehicle mix may vary.

This section reviews the policy strategies that have proven effective for promoting the ZEV transition, and discusses the role of various market actors, including standardization bodies, regulators, and the private sector in that.

Enhanced international cooperation will be crucial to help countries in the Global South (many of which fall in the rest of the world category identified above) to take their full part in the ZEV transition, with ultimate benefits for all. There are many reasons for this. The complexity, novelty and far reaching implications that accompany a global ZEV transition are obviously central. Countries have diverse natural resource endowments, socio-economic and industrial backgrounds, and more or less sophisticated policy development structures. Countries in the Global South are also more exposed to the risk of becoming the dumping ground of vehicles with obsolete technologies from leading markets and close followers and they are also more likely to face financial hurdles (due to higher interest rates) in terms of upfront capital costs.

GFEI activities, reviewed in section 3 of this report, include several initiatives aiming to facilitate exchanges, and enhance global capacity to take action on fuel economy improvement and the ZEV deployment.

More generally, proactive stakeholder engagement, increased ambition and a scaled up capacity from governments are necessary to ensure that the scale up of ZEV is supported in a way that is not only effective to meet the UN Climate Action Pathway, but also aligned with the holistic set of environmental, social development and economic objectives set out in the Sustainable Development Goals.

POLICY ISSUES

In the next section we discuss first **policy approaches promoting the ZEV transition** that have already proven successful, namely:

1. Technical standards and regulations
2. Clear milestones
3. Efficient levels of energy taxes and carbon pricing
4. Procurement policies
5. Economic Incentives
6. Regulatory limits
7. Green investment frameworks

We further highlight three **emerging policy challenges**:

8. Resilient and sustainable supply chains
9. Taxation reform
10. Workforce support

Tables 5 and 6 summarize these and attempt to identify the relevance of the different policy tools and challenges in the four market types identified earlier.

The sections that follow dive deeper in each of these areas, outlining why policy interventions are important, what is the current state of play, how they vary across different markets. It concludes by considering what are the priorities areas for future action.

TABLE 5: Successful policy approaches for the promotion ZEV adoption

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
1) Technical standards and regulations	Technical standards and regulations apply especially to safety and environmental performance of vehicles. They are pre-requisites for scaling up ZEVs and clean energy. They are first developed by *leading markets* and *close followers*, before being adopted elsewhere. A lack of adoption prevents effective policies in developing countries.			
2) Clear milestones	Clear milestones provide important market signals and are especially important to mobilize investments in ZEV production. They are most relevant in *leading markets* and *close followers* that produce vehicles, including emerging economies with large domestic markets. They also matter for countries that are highly endowed with natural resources for battery maufacturing.			
3) Efficient levels of energy taxes and carbon prices	Taxes on fossil energy and other forms of carbon pricing strengthen the cost competitiveness of ZEVs. They are important in all markets. Reforms are a priority where fossil fuels enjoy low tax rates or subsidies. To ensure that fuel economy does not worsen over time, taxation levels also need to adjust as purchase power increases in developing countries.			
4) Procurement policies	Public procurement supports ZEV production and model diversification at an early market stage. It is best suited for vehicles with a high usage profile that are subject to public funding, such as electric buses. *Leading markets* and *close followers* tend to adopt these programs first. Leapfrogging opportunities exist for *aggressive importers* and the rest of the world.			
5) Economic incentives	Economic incentives support the early development of ZEV and the consolidation of their market share. *Leading markets* and *close followers* tend to adopt incentives for vehicles and infrastructure first, where they also serve industrial development. Incentives are also relevant for *aggressive importers*, both for new and used vehicles.			
6) Regulatory limits	Regulatory limits support the transition beyond early development and apply to vehicles as well as charging infrastructure. *Leading markets*, *close followers* and *aggressive importers* tend to implement regulations first. However, they are also important for a resilient technology transition and for keeping out obsolete technologies in rest of the world.			
7) Green investment frameworks	Green investment frameworks are essential to shift capital flows towards expanding ZEV production and low carbon energy. *Leading markets* and *close followers* are ahead of other markets in the development of these frameworks, as they are home to most investment capital and automotive production capacity.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

1) Technical standards and regulations

Technical regulations and standards are important enablers for the safe, environmentally sound and competitive scale-up of clean vehicles. Countries where the automotive industry has a leading role in the economy tend to lead the development of technical standards and regulations for zero emission vehicles. These are often also export-oriented industrial economies and traditionally include Canada, Europe, Korea, Japan and the United States, as well as China, more recently. Emerging economies like India and Russia also take active part in international standard development and are followed by countries with a strong automotive sector in Latin America (Argentina and Brazil) and in the ASEAN region (Indonesia, Malaysia and Thailand).

Technical standards and regulations in low- and middle-income countries tend to follow developments in the regions mentioned above. The complexity and highly technical nature of this work explain this and also point to capacity gaps for emerging economies, which is why supporting these countries to engage with international fora that develop these technical regulations will be important.

These standards and regulations are especially important to accurately measure the energy efficiency and the tailpipe emissions of GHGs and local pollutants, for all vehicle categories/segments - including two/three wheelers, light vehicles (passenger cars) and heavy duty vehicles (trucks and buses). It is vital that these regulations are based on and translate to the real-world performance of vehicles. The Real Urban Emissions Initiative (TRUE) is measuring vehicle emissions on the road - and sharing this information with policymakers and consumers.

Technical standards are especially important for the specific case of ZEVs and their components. This is the case for safety requirements, measurement and minimum requirements on durability and environmental characteristics, including embedded carbon (most relevant for EV batteries). Technical standards are also necessary for devices allowing ZEVs to access to energy. Relevant topics include electricity connectors or hydrogen refuelling, charging/refuelling safety, measuring the carbon content of energy, vehicle to energy infrastructure communication and interoperability across borders.

2) Clear Targets and Milestones

Reaching deep decarbonisation objectives for road vehicles relies on ZEVs becoming the leading vehicle technology. While getting there though, energy use and emissions per km from ICE-powered vehicles must also be reduced. Clear milestones are important and effective in realising this. Adopting intermediate targets for fuel economy improvement and ZEV deployment and embedding them in policy instruments sends clear signals to the vehicle market that there is work to do on existing technologies and new ones, and can assist stakeholders to align the use of available resources with long-term sector goals.

The most ambitious announcements - such as those in Norway and the Netherlands - target a phase-out of passenger cars, light commercial vehicles, urban buses and urban delivery vehicles by 2025. Governments are also beginning to make long-term commitments for a 100% phase out of internal combustion engine medium- and heavy-duty trucks.

3) Efficient levels of energy taxes and carbon pricing

Energy and carbon taxes can encourage vehicle owners and investors to opt for vehicle and fuel technologies with low GHG emission footprint, thus promoting their market growth while alleviating negative externalities from fuel use and production.

Many governments have introduced excise taxes and/or explicit carbon taxes on road transport fuels. Their purpose is to encourage efficient fuel use. They also raise funds for the general budget, and in some cases are used to cover the costs of energy security, to reduce oil import bills, and to improve energy access at affordable cost to all.

Ensuring that fuel prices stimulate energy efficiency will require an increasing price on carbon. It is

particularly important to have this in emerging economies where purchasing power is increasing and where carbon is not currently priced at all. Many such places can be found in the close followers, aggressive importers and rest of world clusters. It is important to adapt fuel taxes regularly in these regions to avoid backsliding on fuel economy and favour greater cost competitiveness for ZEVs.

4) Supportive Procurement Policies

Procurement programs that prioritise zero-emission technologies promote their market growth, especially when the market is at an early stage. The best opportunities arise when the government has a say in large vehicle purchase programs, for instance for government agencies or if large government-controlled companies renew their vehicles. Ordering ZEVs and charging/refuelling infrastructure in bulk can reduce costs per unit, because large orders reduce per-unit transaction costs and reduce risks for manufacturers who scale up production in response.

To maximise benefits and minimise costs, public procurement programmes for zero emission vehicles are best targeted at vehicles with the highest usage levels, as these are the cases where clean technologies offer clear economic advantages. Key examples of these include urban buses, taxis, ride-sourcing and service vehicles (such as garbage trucks), for which public authorities often have regulatory oversight.

5) Economic Incentives

Economic incentives are crucial to scale up the deployment of clean vehicles and the infrastructure they need to have access to energy. They are also well suited to shift consumer choices towards vehicles with better fuel economy, complementing the ZEV contribution to lower emissions from road transport.

Economic incentives can be broadly categorised in two groups:

- Supply-side or "technology push" measures. These are most relevant for advanced technologies, not yet close to market deployment, as they promote investments in R&D and innovation that can later yield cost reductions as well as investments in production facilities.

- Demand-side or "market pull" measures which are better suited to stimulating consumer demand for ZEVs.

Aggressive importers of clean vehicles are (by definition) in a similar situation as leading markets and close followers, as they developed policies favoring energy efficiency and ZEV uptake, leveraging on the policies that are mobilizing supply developments in leading markets and close followers. The most proactive countries in these groups tend to be those where there is local

vehicle manufacturing capacity, a potential to draw significant economic benefits from a ZEV transition (e.g. due to the endowment with materials that are needed for ZEV manufacturing, like nickel and lithium) and where there is greater awareness of environmental impacts of local pollution.

Other emerging markets lag behind on the deployment of economic incentives which would allow them to foster a transition to clean vehicles and clean energy. International support may support them to scale up efforts and to protect from risks of becoming a dumping ground for polluting technologies.

6) Regulatory limits

Regulatory requirements have been crucial in ensuring that fuel-saving technologies increased fuel economy rather than vehicle performance. Governments in *leading markets* (including Europe, Korea, Japan and North America) and *close followers* such as China, have implemented a range of regulatory policies to decarbonize the road vehicles sector. Regulatory limits on clean vehicles include the manufacturing stage, both for the different components and the final assembly. This is especially important In the case of batteries, as already highlighted in the section on technical regulations and standards below. (Table 7) Several markets have set deployment targets for **vehicle chargers and refuelling stations**, yet there is typically no legally binding regulation to support objectives.

7) Green investment frameworks

Public and private investments are an important driver for the market growth of ZEVs once their technologies mature. Incumbent car manufactures as well as emerging EV start-ups rely on the capital markets for funding R&D activities and the expansion in their ZEV productive capacity. Similar considerations apply to companies supplying low-carbon energy.

Development banks and export credit or investment insurance agencies are important players in this area. They must employ a clear definition for green investments to enable technology transfer of ZEV technologies to developing economies, including for example bus fleet conversion projects.

Given the novelty and complexity of these regulations, their application to cases that have a direct relevance for ZEV and clean energy is still at an early stage, and is mainly limited to countries with high degree of political commitment to climate change mitigation and an already strong industrial base. There is therefore the widest gap between leading markets and developing economies where it will be important to strengthen future efforts, in this area. Aggressive importers of clean vehicles have an even stronger case for the adoption of such regulations on sustainable/green finance.

Whilst there is some established good practice in terms of the policy levers identified above, there are still areas where the challenges to widespread ZEV adoption whilst clear, are not yet being addressed.

BOX 2:

ECONOMIC INCENTIVES AROUND THE WORLD

GFEI work focused on South East Asia and the implementation of the ASEAN fuel economy roadmap (ASEAN, 2019) showed recently that Indonesia, Malaysia, Singapore and Thailand have taken steps to develop differentiated vehicle purchase subsidies and/or taxation, based on environmental performances and including specific treatment for ZEVs. Ambitious policies also exist in Latin America, including in Colombia, Chile, Uruguay, Costa Rica, and Panama. These countries already developed national strategies or plans for electric mobility.

EMERGING CHALLENGES

8) Resilient and sustainable supply chains

The growing demand for EVs and the materials required to produce battery systems and electric motors they require comes with both opportunities and challenges.

Opportunities arise in battery and motor production which will in some places lead to the construction of new manufacturing facilities or the conversion or expansion of existing ones. The same is true for raw materials. The demand for battery materials is set to grow dramatically, with demand for lithium for example is set to increase by a factor of 42 between 2020 and 2040.

Governments have a key responsibility to ensure that the shift in material requirements can take place without hitting significant bottlenecks. Both governments and industry also need to make sure that this shift takes place in a way that is environmentally sound and socially sustainable.

Policies aiming to achieve this are being deployed in leading markets and close followers, but more needs to be done in other economies, especially those that host resources needed for the battery, fuel cell and renewable energy value chains.

9) Taxation Reform

Excise taxes on road transport fuels are an important revenue source for many governments. A strong market growth of ZEVs that eventually displaces ICE cars can affect these government revenues and poses policy challenges to the ZEV transition in the long term. A full transition to ZEV sales by 2035, in alignment with the UN Climate Action Pathways targets for leading markets, comes with a cut of average taxation revenues per vehicle of roughly 45% in 2035 and in markets that tax electricity at similar rates as fuels. Revenues will continue to decline after the target year (up to 80%, in 2050) as existing ICE cars reach the end of their lifetime. In markets where the end of ICE sales is envisaged at a later stage, the revenues will decline more gradually, with a drop up to 45% by the target year if electricity taxes are the same (per unit energy) as those on liquid fuels.

Road user charges are a policy solution that offers the possibility to make up for lost fuel-duty

TABLE 6: Emerging policy challenges for the promotion ZEV adoption

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
8) Resilient and sustainable supply chains	Sustainable supply chains are relevant in all markets due to their cross-border nature. *Leading markets* and *close followers* prioritise regulations and other policy frameworks to drive production towards sustainable practices. Markets with lithium and metal reserves that supply battery manufacturing also need to prioritise policies aiming to guarantee sustainable mining.			
9) Taxation reforms	Important to ensure the economic visibility of the ZEV transition that can impact fuel taxation revenues in the long term. Policy responses such as road user chargers rely on rolling out enabling technologies and become first a priority in *leading markets* and *close followers*, which reach a high ZEV market share before other markets.			
10) Workforce support	Supporting the social sustainability of the technology transitions (towards electrification, automation and digitalization) is most relevant for countries with strong automotive industry, which are *leading markets* and *close followers*. Transport electrification with a shift away from fossil fuels will eventually affect the energy sector in all markets.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

TABLE 7: Regulatory frameworks for ZEV deployment, infrastructure and energy supply

AREAS OF INTERVENTION	TYPES OF REGULATORY MEASURE
Vehicle	Pollutant emission regulations/standards Fuel economy/GHG emission regulations/standards LEV/ZEV emission mandates Access/registration/use restrictions (and waivers) in portions of the road network Carbon content and sustainability requirements for key components (batteries)
Energy	Carbon intensity and sustainability requirements of energy vectors Charging/refuelling infrastructure deployment requirements

Source: ITF, 2021

revenues and adequately price the use of vehicles. Addressing congestion emerges as a policy priority especially in markets such as the aggressive importers and rest of world, where the number of vehicles is set to soar.

Currently, policy action on road user charges is limited to very specific experiences, and clearly not yet widespread. Taking into account the pace of change of a ZEV transition that is compliant with the Paris Agreement points to the need to move quickly beyond targeted experiences. This is most relevant for leading markets and close followers, but also important for aggressive importers and the rest of the world, as it requires significant reforms.

10) Workforce support

Economies with large automotive sectors will see structural changes to their industry and labour sectors as the transition to ZEVs proceeds. The switch away from internal combustion engines transforms the needed labour skill sets, not only in the engine manufacturing stage, but also for vehicle maintenance and the supply chains for vehicle and fuel/energy production.

Governments and the private sector need to take proactive and far-reaching action to manage these challenges, particularly where there is already an established car industry (such as those of *leading markets* and *close followers*).

3 GFEI'S ZERO PATHWAY

The GFEI partnership of leading experts has supported countries with fleet transformation via effective policy change for over 10 years. This support is truly global. GFEI is now working in over 100 countries (Table 8), in line with the commitment we made at COP21 in Paris to expand our detailed policy support from around 25 to 100 – an ambitious goal that we are proud to have met.

While we place a strong focus on improving ICE fuel economy with an increasing emphasis on introducing electric vehicles and phasing out internal combustion engine vehicles over time, we also need to ensure that all vehicles are fit-for-purpose particularly in countries where a large part of the fleet is imported second hand, certain safety and quality standards must be met, along with efficiency and electrification targets, so that they do not become the dumping ground for old ICE vehicles. By combining action on fuel efficiency and electrification, the GFEI's targeted support through its ZERO Pathway will work with countries to deliver zero emission vehicles across the globe by 2050.

TABLE 8: GFEI's 100+ countries

EUROPE	Austria	■	■	■
	Belgium	■	■	■
	Bulgaria	■	■	■
	Croatia	■	■	■
	Cyprus	■	■	■
	Czechia	■	■	■
	Denmark	■	■	■
	Estonia	■	■	■
	Finland	■	■	■
	France	■	■	■
	Germany	■	■	■
	Greece	■	■	■
	Hungary	■	■	■
	Ireland	■	■	■
	Italy	■	■	■
	Latvia	■	■	■
	Lithuania	■	■	■
	Luxembourg	■	■	■
	Malta	■	■	■
	Netherlands	■	■	■
	Poland	■	■	■
	Portugal	■	■	■
	Romania	■	■	■
	Slovakia	■	■	■
	Slovenia	■	■	■
	Spain	■	■	■
	Sweden	■	■	■
	UK	■	■	■
EASTERN EUROPE AND THE CAUCUSES	Armenia			
	Georgia	■	■	
	Moldova	■	■	
	Montenegro	■	■	■
	North Macedonia	■	■	
	Russia			
	Turkey	■		
	Ukraine	■	■	■
MIDDLE-EAST, WEST ASIA, AND CENTRAL ASIA	Bahrain	■		
	Iran	■		
	Kazakhstan	■	■	
	Lebanon	■		
	Saudi Arabia	■	■	■
	UAE	■	■	■
	Uzbekistan			
ASIA PACIFIC	Australia			
	Bangladesh	■	■	
	Cambodia	■	■	
	China	■	■	■
	Fiji	■		
	India	■	■	■
	Indonesia	■	■	
	Japan	■	■	■
	Laos			
	Malaysia	■	■	■
	Maldives			
	Mongolia	■	■	
	Myanmar	■		
	Nauru	■	■	
	Nepal	■	■	
	New Zealand	■	■	■
	Pakistan	■		
	Philippines	■	■	■
	Singapore	■	■	■
	South Korea	■	■	■
	Sri Lanka	■	■	■
	Thailand	■	■	■
	Vietnam	■	■	■
LATIN AMERICA AND CARIBBEAN	Antigua and Barbuda			
	Argentina	■	■	■
	Belize	■		
	Brazil	■	■	■
	Chile	■	■	■
	Colombia	■	■	■
	Costa Rica	■	■	■
	Dominican Republic	■	■	■
	Ecuador			
	El Salvador	■		
	Guatemala	■		
	Honduras	■		
	Jamaica	■	■	
	Nicaragua			
	Panama	■		
	Paraguay	■	■	
	Peru	■	■	■
	St. Lucia			
	Uruguay	■	■	■

KEY

- ■ Baseline completed
- ■ Policy Implemented
- ■ Policy recommendations
- ■ G20 TTG member
- ■ ECOWAS
- ■ ASEAN

NORTH AMERICA	Canada	■	■	■
	Mexico	■	■	■
	US	■	■	■
AFRICA	Algeria	■		
	Benin	■		
	Botswana	■		
	Burkina Faso	■	■	
	Burundi			
	Cabo Verde			
	Cote d'Ivoire	■	■	
	Egypt	■		
	Ethiopia	■	■	
	Gambia	■	■	
	Ghana	■	■	
	Guinea	■		
	Guinea Bissau	■	■	
	Kenya	■	■	■
	Liberia	■		
	Madagascar			
	Malawi	■		
	Mali	■	■	
	Mauritius	■	■	■
	Morocco	■		
	Mozambique	■	■	
	Namibia	■	■	
	Niger	■		
	Nigeria	■	■	
	Rwanda	■	■	■
	Senegal	■	■	
	Seychelles			
	Sierra Leone	■		
	South Africa	■	■	
	Tanzania	■		
	Togo	■	■	
	Tunisia	■		
	Uganda	■	■	
	Zambia	■		
	Zimbabwe	■		

BOX 3:

THE GLOBAL FUEL ECONOMY INITIATIVE'S 'ZERO PATHWAY INITIATIVE' (ZERO)

The ZERO pathway builds on previous experience to support a global transition to zero carbon vehicles in line with many of the most ambitious national and global plans. We will draw on demonstrated strategies from successful countries around the world, including those outlined above.

At the heart of the GFEI's approach will be a strong commitment to **capacity-building**, sharing of experience and supportive interaction. This work is vital, often overlooked and never properly funded. A key recommendation of this report is that capacity building work in the field of the promotion of EVs be properly funded in the future.

Central to that capacity-building are the sorts of tools - currently embodied in the GFEI's ZERO Pathway Toolkit - already deployed in leading markets and some aggressive followers, but much needed at some point along the path to fleet transformation in the other market groupings also. From technical and regulatory standards to economic Incentives, green investment frameworks to modified procurement practices, the transformation which we seek must be supported by **a framework of policy**.

It is also essential that the issues of fuel efficiency in ICE vehicles and the promotion of electrification are not seen as competing but rather as complementary measures requiring the continued use of policy such as **vehicle standards for CO_2 emissions in ICE vehicles,** and **incentives for the take-up of EVs**.

An **end to the subsidisation of fossil fuels** is an essential prerequisite in this area, as is the vigorous promotion of renewable energy sources.

Finally, and regardless of progress with electrification, the only true path towards achieving the Paris targets must include far more **non-motorised mobility - walking and cycling**, as well as more shared mobility that is effectively integrated with high-capacity public transport services.

THE GFEI APPROACH

GFEI projects are delivered as part of an integrated training that focuses on air quality and climate change, covering ways to reduce pollutant emissions through vehicles and fuels, ways to improve vehicle efficiency, and the transition to electric mobility.

GFEI's approach has been to support the promotion of vehicle efficiency in three main ways:

1. **Advocacy** at the global level to ensure sufficient attention is trained on this vital aspect of energy efficiency and vehicle regulation.

2. **Research and data** is essential both in terms of understanding some key issues and challenges such as the role of secondhand markets. GFEI has an extensive series of working papers and reports on such issues and has also established the only global data series monitoring the changes and developments in terms of fuel economy since 2005.

3. **Capacity building** is perhaps the most important component of the GFEI approach. The GFEI partners are experts in offering support and insights to policy makers. ICCT in particular have provided support and analysis to inform standards around the world including China, the EU, US and many other markets such as India, South Africa, and Mexico. This work, which is undertaken at national and regional levels is described in greater detail below.

I) Capacity building at country level

Countries need support to fully understand the options which are available; to appreciate their own fleet and projections for its growth; and to develop plans of action which are appropriate to their circumstances. Section 2 above laid out many of these policy options.

GFEI's support to countries takes four main forms:

1. **Baseline** - it is essential to fully understand the starting point when any form of policy change or new framework is being considered, and when it comes to evaluating progress. Many countries do not have a full understanding of the scale, scope and form of their domestic fleet. Developing a baseline of this nature is therefore an essential under-pinnig of good policy, and GFEI supports this process with a range of tools. More than 70 countries have now developed a baseline with GFEI support.

2. **FEPIT** - it is equally important to fully understand how global and local trends may affect each country. The FEPIT tool which was developed by IEA and UNEP allows policy officials to cast forward and model likely changes in the demand for certain types of vehicles. This is a very useful 'counter-factual' against which policy changes can be measured, and again can be useful in evaluation.

3. **Stakeholder engagement.** It is vital when considering such momentous policy developments to try to take on board the perspectives of as many of those groups who are likely to be impacted by the changes as possible. The GFEI team supports officials in drawing together the relevant stakeholders from manufacturers to consumer groups, other Government departments to international advisers.

4. **Toolkit** - The GFEI toolkit (see Box 4) is a unique set of tools gathered over many years and from many places which enables any country to consider the options available to them in terms of promoting greater vehicle efficiency. From fiscal measures to better labelling, the measures contained in the toolkit are tried and tested approaches.

BOX 4:

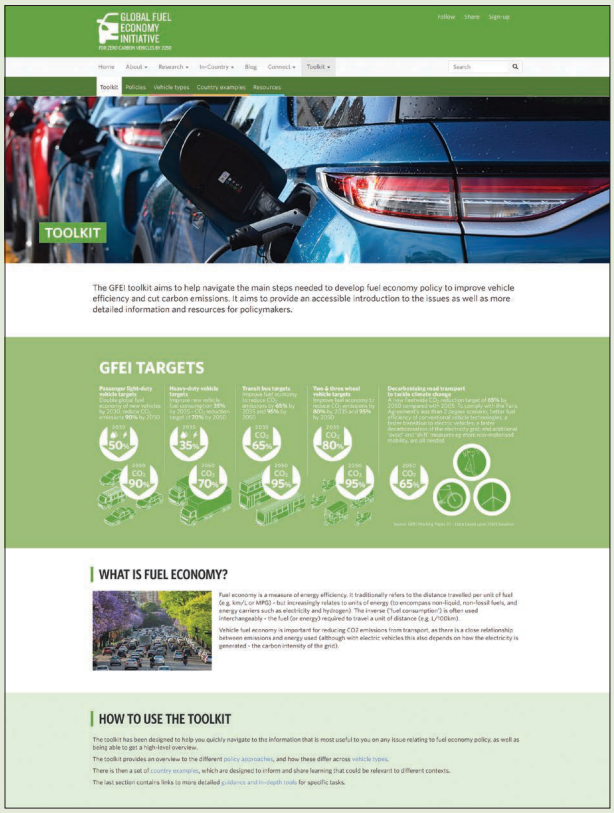
THE GFEI TOOLKIT

The GFEI toolkit aims to help navigate the main steps needed to develop a fuel economy policy to improve vehicle efficiency and cut carbon emissions. It aims to provide an accessible introduction to the issues as well as more detailed information and resources for policymakers.

The toolkit provides information about how to establish a baseline of vehicle data for a country, and then assess the potential impact of developing policy options using modelling tools. It also sets out a useful introduction to key issues such as vehicle size and the rise of SUVs, the transition to electric vehicles, and a focus on heavy-duty trucks and motorbikes as well as passenger cars.

It also includes links to further resources developed by GFEI's expert partners on specific topics, such as UNEP's eMOb calculator – which can help estimate the potential of saving energy, greenhouse gas and air pollutant emissions as well as money through a dedicated shift to electric mobility.

Around the world, many countries have made policy changes as a result of GFEI's support – with some having introduced several phases of improvements. This is vital. As technology progresses, and as targets are met, it is important that countries continue to develop their approaches.



THE GLOBAL ELECTRIC MOBILITY PROGRAMME

GFEI is a delivery partner for the GEF funded 'Global Electric Mobility Programme' (GEMP). As such, we will support work in 50 countries - many of whom began their journey through GFEI, and some of whom are identified in Table 9 below.

COUNTRY CASE STUDY: SRI LANKA

GFEI supported Sri Lanka in the development of their roadmap for cleaner fuels and vehicles, and subsequently on improving the efficiency of the vehicle fleet through their vehicle excise tax system. The country adopted draconian vehicle excise tax for gasoline and diesel vehicles in 2015 as high as 250% and 350% tax on imported new and second-hand vehicles, while keeping the tax for hybrid at 50% for gasoline vehicles with engine size less than 2,000cc, and 70% for diesel vehicles less than 2,000cc and BEV new and second-hand vehicles at about 25%. The policy resulted in a rapid uptake of hybrid and BEVs in the country improving the overall fuel economy of the vehicles. UNEP is now supporting the country in developing a national e-mobility program with support from the GEF.

COUNTRY CASE STUDY: MAURITIUS

Mauritius is perhaps the first developing country to adopt a feebate scheme to promote more efficient vehicles. GFEI supported the country as early as 2011 when the country adopted a CO_2-based feebate scheme which puts a fee of 55$ per g/km for cars with CO_2 ratings above 158CO_2g/km; and a rebate of 27$ per g/km for cars with CO_2 ratings from 91 to 158 CO_2 g/km and 82$ for cars below 91 CO_2g/km. The policy led to an improvement of the fuel economy of the light-duty vehicle fleet from 7 L/100km in 2005 to 5.8 L/100km in 2014, and a rapid increase in the number of hybrid vehicles. In 2019, with GFEI support, the country shifted to a straight vehicle excise taxation with 0% excise for electric cars less than 180kW and 25% above 180kW and for hybrid vehicles – 25% for cars below 1,600cc; 45% for cars 1600-2000cc, and 70% for cars above 2000cc. The country is now also developing a national e-mobility program as part of the global electric mobility programme.

COUNTRY CASE STUDY: CHILE

Chile was one of four pilot countries who started working with GFEI in 2009 and completed a baseline analysis of vehicle fuel economy in 2010. As a result, it became the first country in Latin America to adopt fuel economy vehicle labelling in 2013, and subsequently introduced a green tax in 2014, targeting carbon emissions. In 2021, it adopted the

TABLE 9: GEMP supported countries

Africa		Asia		Central & Eastern Europe, West Asia, Middle East		Latin America & the Caribbean	
Burundi	UNEP	Bangladesh	UNDP	Albania	UNIDO	Antigua & Barbuda	UNEP
Cote d'Ivoire	UNEP	India	UNEP / ADB	Armenia	UNEP	Costa Rica	UNEP
Madagascar	UNEP	Indonesia	UNDP	Belarus	UNDP	Chile	UNEP
Mauritius	UNDP	Maldives	UNEP	Jordan	UNIDO	Ecuador	UNEP / SOL+
Rwanda	UNEP / SOL+	Nepal	SOL+	Ukraine	UNEP / EBRD	Grenada	UNEP
Senegal	UNEP	Philippines	UNEP / SOL+	Uzbekistan	UNDP	Jamaica	UNDP
Seychelles	UNEP	Sri Lanka	UNEP			Peru	UNDP
Sierra Leone	UNEP	Thailand	UNEP			St. Lucia	UNEP
South Africa	DBSA	Viet Nam	UNEP / SOL+			Uruguay	SOL+
Tanzania	UNEP / SOL+						
Togo	UNEP						
Tunisia	UNIDO						

Source: UNEP, 2021

country's first Energy Efficiency Law, which is part of its efforts to achieve carbon neutrality by 2050. The law requires the Ministry of Energy to prepare a national energy efficiency plan every five years. The first plan is required to address the goal of reducing the energy intensity by at least 10% by 2030.

Chile has just launched a new electric mobility strategy which will ban the sale of non-ZEVs by 2035 and is planning to introduce new fuel economy standards to accelerate the transition – the first in Latin America.

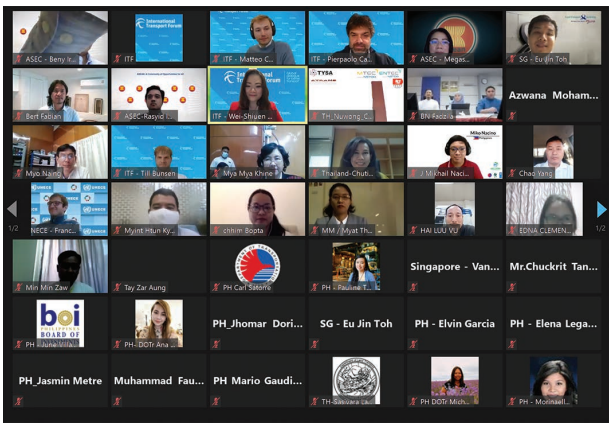
COUNTRY CASE STUDY: UKRAINE

GFEI is working with Ukraine to implement policies to support more efficient and electric vehicles. In 2018 UN Environment, together with the International Standardization Academy of Ukraine, and the Ministries of Infrastructure and of Internal Affairs jointly undertook a baseline study which examined the country's vehicle imports between 2005 and 2016. Ukraine has actively sought to grow its market for EVs in recent years, seeing rapid growth by exempting them from import taxes and VAT. It has set ambitious goals to phase out the sales of used diesel vehicles by 2027 and new ICE vehicles by 2030.

II) Regional Support

International cooperation and harmonisation of standards can both lower the costs of implementing and enforcing regulations such as fuel economy standards, and provides a valuable basis for engagement to achieve broader societal and environmental goals (including climate).

GFEI is providing support to officials from across the ASEAN region to improve vehicle efficiency. In January representatives from the ASEAN Secretariat and all ten ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam) met to discuss progress and next steps. Following the adoption of the ASEAN Fuel Economy Roadmap in 2018, GFEI partners UNEP and the International Transport Forum have been providing support. The roadmap aims to reduce fuel consumption by 26% by 2025 compared with 2015 levels, as well as agreeing common indicators and methodologies, fuel economy labels and potentially introducing new fiscal policies and standards – aiming to work towards a regional standard.



REGIONAL CASE STUDY: AFRICA

While much focus at the moment is on the leading edge of transition to electric passenger vehicles, it is also vital to remember that the majority of people globally live in developing or middle-income countries. GFEI has worked with around 30 countries from across Africa, and is working with more through regional groups, including in West Africa where ECOWAS adopted the first ever African regional fuel economy roadmap.

In many of these countries, the major issues are around the fuel quality and the importation of used vehicles, as well as emerging trends for increasing

motorisation through rising numbers of motorbikes. While GFEI is also preparing these countries to adapt to the new electric vehicle revolution, for many this may be initially focused on electric motorbikes as a more affordable entry point for cutting emissions, alongside preparatory policies to enable the transition to electric vehicles. Through UNEP, there has also been a new focus on the dumping of dirty second-hand vehicles in Africa, and there has been recent success with the Dutch government putting restrictions on second-hand vehicle flows to Africa through its ports.

UNEP is working closely with governments in Kenya, Uganda, Rwanda, and Ethiopia to develop comprehensive policy frameworks and recommendations to spearhead the transition and adoption of electric mobility within the region. The Kenyan government has already committed to implement fiscal incentives for electric vehicles to help meet the government's target of 5% of all newly registered vehicles to be electric by 2025.

III) Specialist support to global processes

The GFEI engages in all of the relevant global policies and processes from the UNFCCC climate discussion to Sustainable Energy for All (SE4ALL), and from the World Bank's Sustainable Mobility for All initiative (SUM4ALL) to the global alliance of low carbon initiatives The Sustainable Low Carbon Transport Alliance (SLOCAT). Some of these groupings have political and policy agendas, others shape opinion and raise awareness. GFEI has endeavoured to ensure that the issues around more efficient vehicles are appropriately reflected in them all.

SPECIALIST SUPPORT CASE STUDY: THE G20

GFEI provides support to the Transport Task Group of the G20. This forum of countries includes many of the largest vehicle markets. GFEI, together with our partner ICCT have provided capacity building and support to this group, with a particular focus on developing policy on Heavy-Duty Vehicles, particularly fuel economy standards.

GFEI will continue to work to raise these issues at country, regional and the global level, to ensure that a global perspective on vehicle policy is considered that results in cleaner low-carbon mobility in Liberia as well as London, or Patagonia as well as Paris. It is a vital part of the wider 2030 sustainable development agenda, and while this is in many ways about cutting edge innovation increasing vehicle range, and battery technology – it also is about making mobility work for the poorest communities, and ensuring they have access to opportunities and goods and services for mutual prosperity, as well as protecting the planet and supporting people's health and livelihoods.

SPECIALIST SUPPORT CASE STUDY: THE UNFCCC - DELIVERING ON PARIS

In 2015 in Paris, GFEI committed to an ambitious expansion to rapidly extend policy support for cleaner, more efficient vehicles to over 100 countries. This has been achieved through a combination of country projects, implemented with the support of the GEF, European Commission and FIA Foundation and in an exciting development, the establishment of new regional commitments to reducing emissions from vehicles– particularly in West Africa (ECOWAS) and South-East Asia (ASEAN) which have both agreed fuel economy roadmaps, as well as key strategic support to the largest economies through the G20 Transport Task Group. GFEI has supported, or is currently working with, 35 countries in Africa, over 20 in Asia and the Pacific, 19 in Latin America and the Caribbean, and over a dozen more across Eastern Europe, West Asia and the Middle East, as well as to Europe and North America.

Ahead of COP26 in Glasgow, parties to the UN Framework Convention on Climate Change (UNFCCC) were requested to submit updated or second Nationally Determined Contributions (NDCs), setting out their commitments to tackling climate change. By 1 May 2021, 54 new or updated NDCs had been submitted, which were then analysed by SLOCAT and GIZ as part of their Tracker of Climate Strategies for Transport. Out of these new NDC submissions, 10 are officially titled as second NDCs, while the remaining 44 have been submitted as updates to their first NDC. Countries whose first NDC spanned a timeframe of up to 2025 had to submit their second NDC, while NDCs with a timeframe of up to 2030 had to be updated.

As Figure 10 shows, 39 of the new NDCs (72%) highlight transport in their mitigation actions, with more than 230 mitigation measures referenced in NDCs. They conclude that NDCs focus mainly on fuel and efficiency improvements (shown under 'low carbon fuels and energy vectors'), with 33 in this category. These standard categories are based on the classification in ITF's Transport Climate Action Directory Transport Climate Action Directory.

FIGURE 9: GFEI's 100 countries

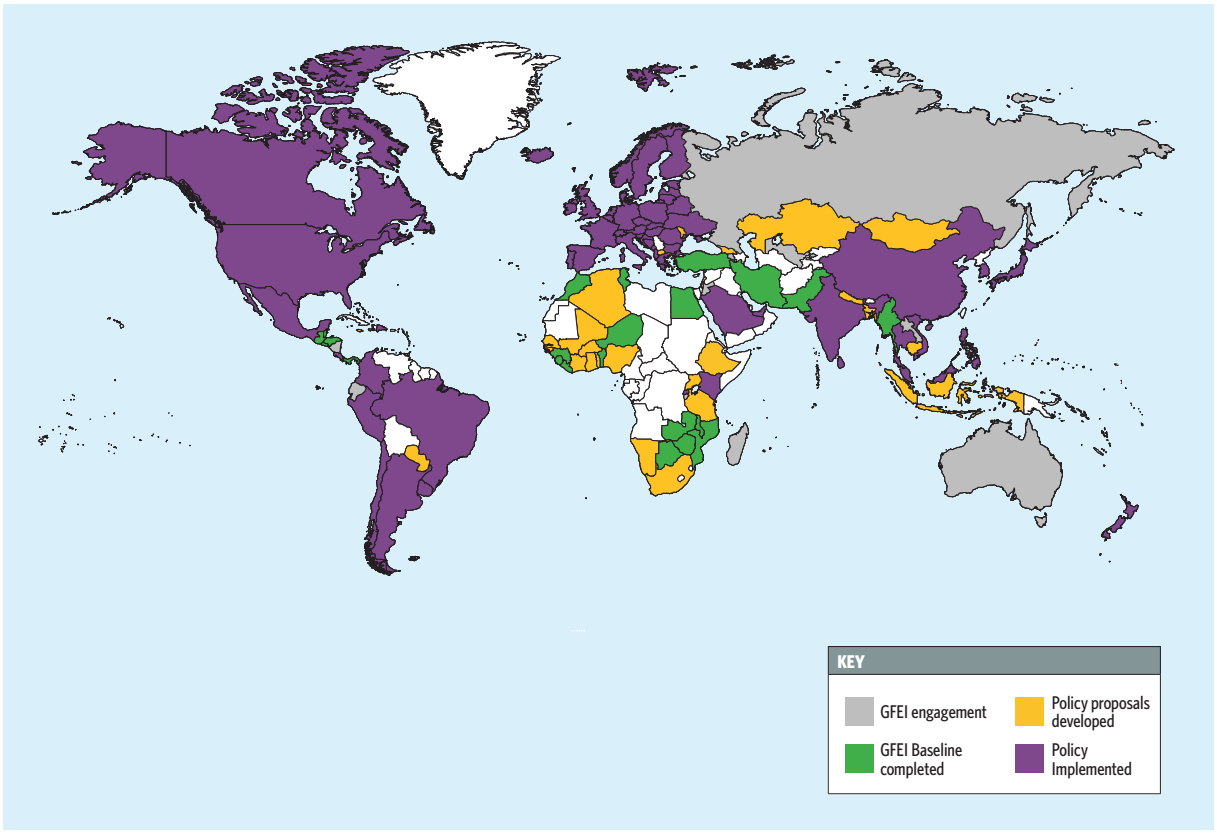
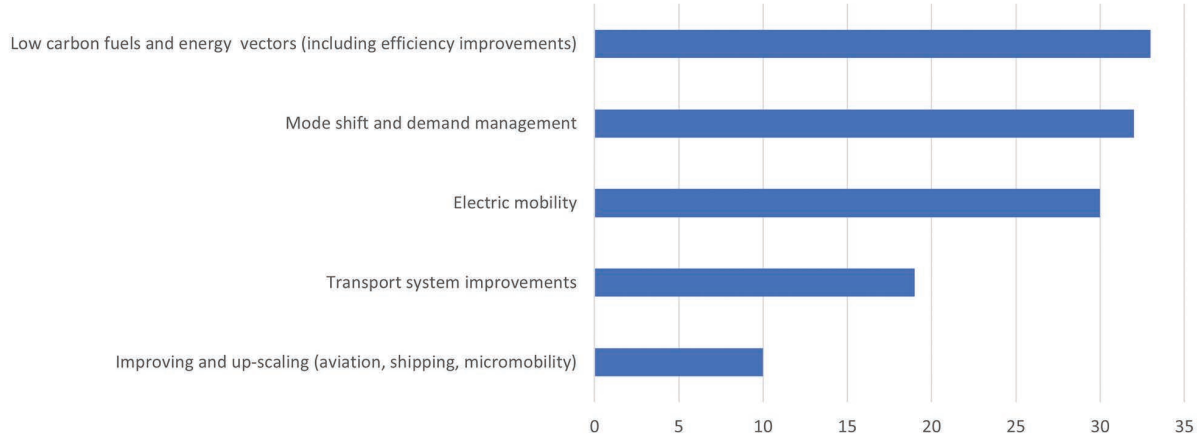


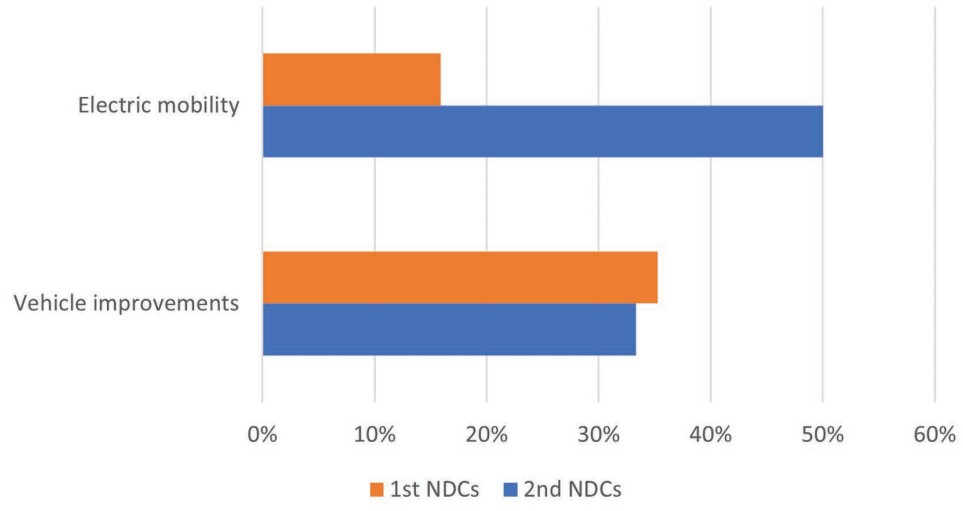
FIGURE 10: Thematic areas of transport references in new NDCs



Source: SLOCAT summary analysis

The largest change relating to transport observed between first and second NDCs is a far higher proportion in the new documents now include a focus on electric mobility (Figure 11). This is not a direct like-for-like comparison, as it is not an identical mix of countries, but is a strong indicator that electric mobility is becoming more of a priority in countries' decarbonization plans. Vehicle improvements continue to be an important theme, and covers fuel economy standards or other policies or targets for improving the efficiency of the vehicle fleet.

FIGURE 11: 2nd NDCs and electric mobility



Source: SLOCAT Climate Tracker - analysis in numbers

Countries that GFEI partners have provided policy support to are among those who have submitted their new or updated NDCs (Table 10). These NDCs include a range of targets, and commitments around supporting improved vehicle efficiency, and a shift to electric mobility. Thailand and Lebanon highlighted tax changes to support low carbon vehicles, while Nepal, Chile and Bangladesh highlighted targets for the transition to electric vehicles. Argentina highlighted its recent vehicle efficiency scheme which was implemented with the support of GFEI.

TABLE 10: GFEI supported countries' NDC submissions

COUNTRY	NDC	THEME	DESCRIPTION
Argentina	2nd NDC	Labelling	Vehicle energy efficiency labeling
Bangladesh	Updated NDC	E-mobility	10000 hybrid and electric vehicles are planned to be introduced, and the removal of 86,000 unfit vehicles from the roads
Cambodia	Updated NDC	E-mobility	E-mobility
Chile	Updated NDC	E-mobility	Targets for electric taxis, buses, passenger and commercial vehicles
Dominican Republic	Updated NDC	E-mobility	Policy frameworks to enable transition to electric vehicles
Lebanon	Updated NDC	E-mobility	Tax exemptions for electric vehicles
Nepal	2nd NDC	E-mobility	Targets for electric vehicles (90% by 2030 for private vehicles)
Senegal	Updated NDC	E-mobility	Promotion of hybrid vehicles
Thailand	Updated NDC	Vehicle tax	A vehicle tax scheme based on CO_2 emissions was introduced in 2016 to promote low carbon vehicles.
Viet Nam	Updated NDC	Vehicle efficiency	Improving the energy efficiency of transport vehicles

CONCLUSIONS

GFEI partners have found that with a strong commitment to fuel economy improvement and electrification, deep reductions can be achieved by 2050 across road transportation systems worldwide.

With leading economies moving very rapidly toward electrification (targeting 75% of LDV sales by 2030), and other types of economies following 5-10 years after, the world can achieve near-universal electrification of vehicle stocks by 2050; certainly by 2060. Reducing the carbon intensity of electricity generation around the world must occur in lock-step for this approach to provide full CO_2 reduction benefits.

It is vital however that a strong policy framework which includes the policies identified above, is put in place to support this transition. Further specific support to less developed economies, such as that which is currently delivered by GFEI, is also essential.

GFEI's **ZERO pathway** builds on over a decade practical support to over 100 countries to develop low-carbon and fuel-efficient vehicle policies. At the heart of this approach is a strong commitment to capacity-building, sharing of experience and supportive interaction. This means:

- The promotion of **electrification** and ongoing improvements in **fuel efficiency** of ICE vehicles must not be seen as competing, but rather as complementary measures.

- Both require the **continued use of a range of policy instruments**, including the **removal of fossil fuel subsidies**, the use of **fossil fuel taxes and carbon pricing** mechanisms, **tightened regulations for tailpipe CO_2 emissions, and the carbon content of fuels,** and **economic incentives for energy efficient vehicles**.

- **The transition to Zero Emission Vehicles (ZEVs) requires additional policy tools**, including the development of **technical standards, public procurement** programmes, **power sector reforms** allowing optimisation of EVs and renewable or low-carbon electricity, **economic measures and regulatory requirements** stimulating **demand for electric vehicles (EVs) in the market** and the deployment of the **charging infrastructure** that they need.

- **ZEVs also require policies** aiming to ensure that the **materials required for batteries and renewable electricity are available and sustainably sourced and handled at the end of their useful life**, that potential **shortfalls in government revenues from a shift away from fossil energy can be managed,** and that the implications of this technology transition (along with the digital one) on **jobs can result in net benefits for the workforce**.

- **Mobilising investments** towards clean vehicles and clean energy will also be essential to achieve the transition successfully. Regulations clarifying which activities are aligned with **sustainable finance requirements** will have a crucial importance to achieve this, for developed and emerging economies.

- Given the complexity of this set of policies, achieving a truly global transition will require that governments – especially in emerging economies – are effectively supported by significant **capacity-building** activities, enabling them to leapfrog to ZEVs at affordable costs and avoid becoming the dumping ground for used combustion engine vehicles, with greater exposure to increased volatility of fossil fuel prices.

Finally, and regardless of progress with electrification, the only true path towards achieving the Paris targets must also include changes in the types of vehicles used, including more **non-motorised mobility – such as walking and cycling, and shared mobility that is effectively integrated with high-capacity public transport services**.

ANNEX

POLICY APPROACHES PROMOTING THE ZEV TRANSITION (ADDITIONAL DETAIL)

1) Technical standards and regulations

Technical regulations and standards are important enablers for the safe, environmentally sound and competitive scale-up of clean vehicles and energy vectors. Regulators and standardisation bodies in leading vehicle markets have embedded the specific needs of zero (tailpipe) emission vehicles (ZEVs), low-carbon energy vectors and their transport and distribution infrastructure (ITF, 2020a; ITF, 2021). Standardisation work has also allowed vehicles to access energy sources, pay for the energy they use and, more broadly, improve the integration of innovative vehicle technologies in an evolving energy and digital communication environment.

Countries where the automotive industry has a leading role in the economy tend to lead the development of technical standards and regulations for zero emission vehicles. These are often also export-oriented industrial economies and traditionally include Canada, Europe, Korea, Japan and the United States, as well as China, more recently. Emerging economies like India and Russia also take active part in international standard development and are followed by countries with a strong automotive sector in Latin America (Argentina and Brazil) and in the ASEAN region (Indonesia, Malaysia and Thailand). Technical standards and regulations in low- and middle-income countries used to follow developments in the regions mentioned above. The complexity and highly technical nature of this work may come with capacity gaps for emerging economies, which is why supporting these countries to engage with international fora that develop these technical regulations will be important.

The transition to new energy sources is a fast-moving and changing landscape, and more will be needed to enable continued technological developments in the future (ITF, 2020a). For example, the standards for batteries of electric trucks and corresponding charging infrastructure, which both come with higher capacity requirements than electric cars. Similarly, existing standards fall short of accommodating fuel cell electric trucks and their charging stations, which have specific requirements due to larger on-board hydrogen tanks and higher refuelling pressure compared to fuel cell electric cars.

TABLE 11: Technical standards and regulations

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
1) Technical standards and regulations	Technical standards and regulations apply especially to safety and environmental performance of vehicles. They are pre-requisites for scaling up ZEVs and clean energy. They are first developed by *leading markets* and *close followers*, before being adopted elsewhere. A lack of adoption prevents effective policies in developing countries.			

Legend

- Most relevant/urgent need for action to stimulate development
- Cases requiring action, but also with greater scope for spill over effects

Technical standards and regulations are also important to accurately measure the energy efficiency and the tailpipe emissions of GHGs and local pollutants, for all vehicle categories/segments (including two/three wheelers, light vehicles (passenger cars) and heavy duty vehicles (trucks and buses). Measuring the environmental performance of vehicles relies on a combination of test cycles, dynamometer tests, simulation tools and real-world testing. Promoting international harmonisation of these instruments is a priority, There are some other key areas for action:

- Tests should be improved for plug-in electric vehicles (PHEV), in particular with respect to the share of all-electric driving, to avoid discrepancies with real-world emissions (ICCT, 2020).

- Further work is also needed to develop life cycle assessment of emerging technologies used for the production of transport fuels and electricity. This is especially important for options using hydrogen, an energy carrier or a feedstock for fuel production that can come from a variety of processes and primary energy forms (ITF, 2020a).

- Producing a ZEV also comes with a larger environmental footprint than for conventional cars. This is mostly because vehicle battery production is resource-intensive. The manufacturing footprint of ZEVs also has a significantly higher share in the vehicle lifetime impacts than for conventional technologies. This is because emissions and energy use from vehicle operations are small. Regulations to better account for these manufacturing emissions, such as a recent European Commission proposal for a new Battery Regulation (see Note 1) (EC, 2020a, EP, 2021), are vital.2

2) Clear Milestones

Reaching deep decarbonisation objectives for road vehicles relies on ZEVs becoming the leading vehicle technology. While getting there though, energy use and emissions per km from ICE-powered vehicles must also be reduced. Clear milestones are important and effective in realising this. Adopting intermediate targets for fuel economy improvement and ZEV deployment and embedding them in policy instruments sends clear signals to the vehicle market that there is work to do on existing technologies and new ones, and can assist stakeholders to align the use of available resources with long-term sector goals.

All of the leading markets as defined in this work, have adopted fuel economy improvement and ZEV deployment targets (IEA, 2021; ITF, 2021). Whilst their level of ambition varies, the growing awareness that setting a clear vision will not only reduce energy use, GHG and air pollutants emissions, but also foster industrial development, is an encouraging signal for the future. Several vehicle markets have gone a step further than just the deployment of targets, and have pledged to fully phase out sales of ICE vehicles. These markets represent over 10% of global light-duty vehicle sales today and include transition leaders (*leading markets*, e.g. France, United Kingdom) as well smaller markets with strong ZEV ambitions (*aggressive importers*, e.g. Cabo Verde, Costa Rica).

The most ambitious announcements - such as those in Norway and the Netherlands - target a phase-out of passenger cars, light commercial vehicles, urban buses and urban delivery vehicles by 2025). Others such as Denmark, Iceland, Ireland, Israel, the Netherlands, Singapore, Slovenia, Sweden and the United Kingdom have targeted an end to sales of ICE passenger cars by 2030, as Figure 12 shows.

TABLE 12: Clear milestones

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
2) Clear milestones	Clear milestones provide important maret signals and are especially important to mobilize investments in ZEV production. They are most relevant in leading markets and close followers that produce vehicles, including emerging economies with large domestic markets. They also matter for countries that are highly endowed with natural resources for battery manufacturing.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

Governments are also beginning to make long-term commitments for a 100% phase out of internal combustion engine medium- and heavy-duty trucks. As Figure 13 shows, Austria, Cape Verde, Norway, and Pakistan, as well as the regional governments of California and the southern Chinese province of Hainan,have made such commitments (ICCT, 2021b).

3) Efficient levels of energy taxes and carbon pricing

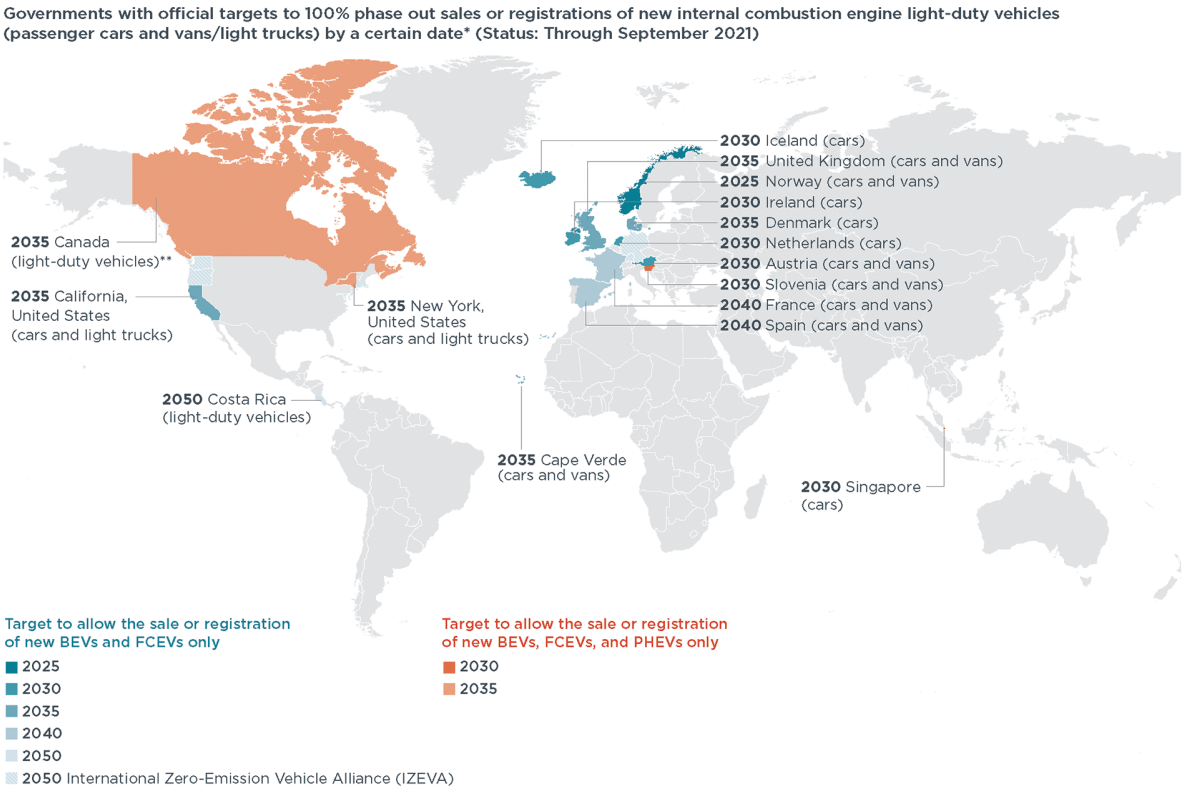
Energy and carbon taxes can encourage vehicle owners and investors to opt for vehicle and fuel technologies with low GHG emission footprint, thus promoting their market growth while alleviating negative externalities from fuel use and production.

Many governments have introduced excise taxes and/or explicit carbon taxes on road transport fuels. Their purpose is to encourage efficient fuel use. They also raise funds for the general budget, and in some cases are used to cover the costs of energy security, to reduce oil import bills, and to improve energy access at affordable cost to all. Taxes on road transport fuels tend to be higher per energy unit than for other end users, such as the residential or industry sectors. Electricity is typically not subject to transport fuel taxes. In Europe, recent proposals to reform energy taxation recommend lower tax rates for electricity than for other fuels in order to promote electrification of end-use sectors.

Available data on international road fuel prices (GIZ, 2020, Lattanzio and Bizeul, 2021) clusters countries into three main groups:

- **Subsidies** - Jurisdictions that apply fuel prices that are below the cost of crude oil, and therefore provide significant subsidies to road transport fuels. These tend to include economies that are highly dependent on fossil fuel revenues, spanning

FIGURE 12: Governments with official targets to 100% phase out sales or registrations of new ICE cars by a certain date (as of June 2021)



* Includes countries, states, and provinces that have set targets to only allow the sale or registration of new battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs). Countries such as Japan with pledges that include hybrid electric vehicles (HEVs) and mild hybrid electric vehicles (MHEVs) are excluded as these vehicles are non plug-in hybrids.
** The Canadian province of British Columbia has set its 2040 target into binding regulation; the Canadian province of Québec has also set a target for 2035.

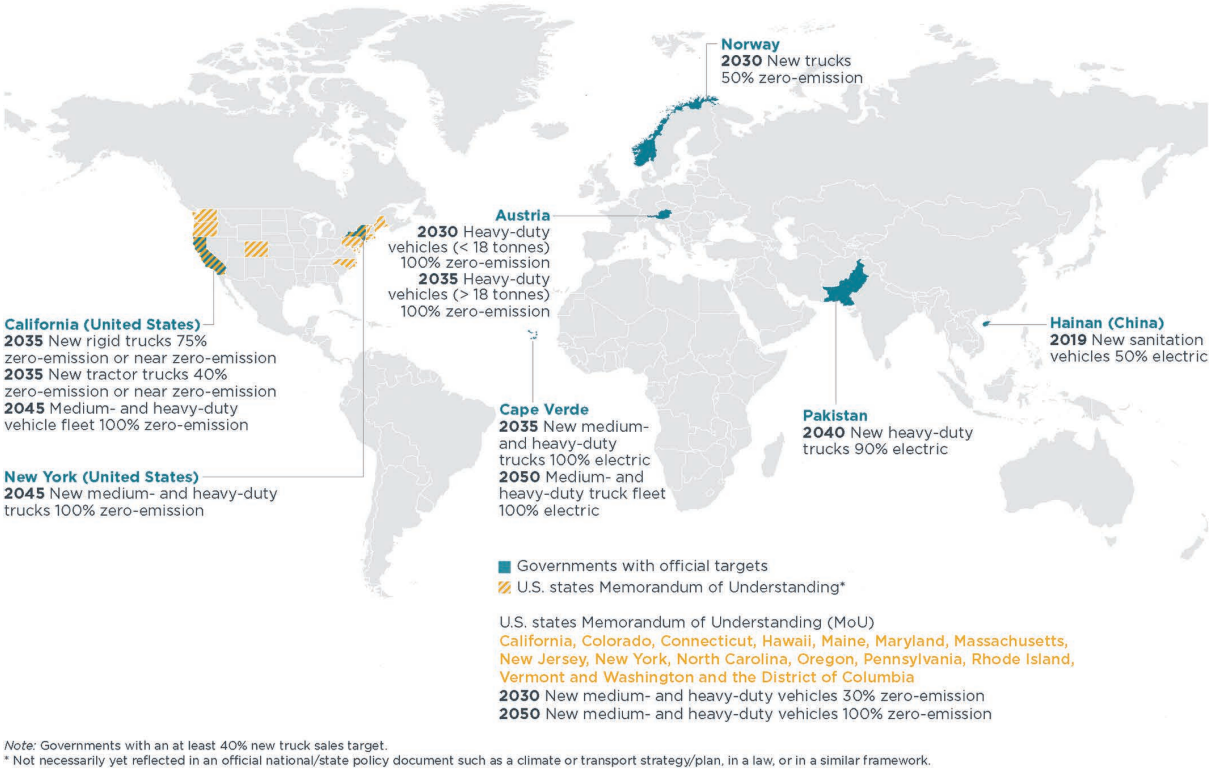
Source: ICCT, 2021a

across low- to middle-income levels and include several of those located in North Africa and the Middle East, as well as some economies in Central Asia, South East Asia and Latin America.

- **Non-subsidised** - Taking the US as the minimum benchmark for non-subsidized road fuel tax policy (GIZ, 2020), this group includes a wide range of low- to middle-income countries, such as China, India, Australia and Canada.

- **Revenue-raising** - This group includes countries that apply a net taxation rate that is significantly higher than the United States, such as European countries and other developed economies such as Korea and Japan.

FIGURE 13: Governments with targets towards phasing out sales of ICE trucks by a certain date (as of August 2021)



Note: Governments with an at least 40% new truck sales target.
* Not necessarily yet reflected in an official national/state policy document such as a climate or transport strategy/plan, in a law, or in a similar framework.

Source: ICCT, 2021b

TABLE 13: Efficient levels of energy taxes and carbon pricing

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
3) Efficient levels of energy taxes and carbon prices	Taxes on fossil energy and other forms of carbon pricing strengthen the cost competitiveness of ZEVs. They are important in all markets. Reforms are a priority where fossil fuels enjoy low tax rates or subsidies. To ensure that fuel economy does not worsen over time, taxation levels also need to adjust as purchase power increases in developing countries.			

Legend

- Most relevant/urgent need for action to stimulate development
- Cases requiring action, but also with greater scope for spill over effects

As Figure 14 below shows, considering purchasing power parities (PPPs) between regions when comparing fuel prices shows that fuel taxes in some emerging economies are effectively comparable to those applied in the third cluster considered above. India and Turkey,in particular, have significantly higher fuel price levels (considering PPP) than remaining regions.

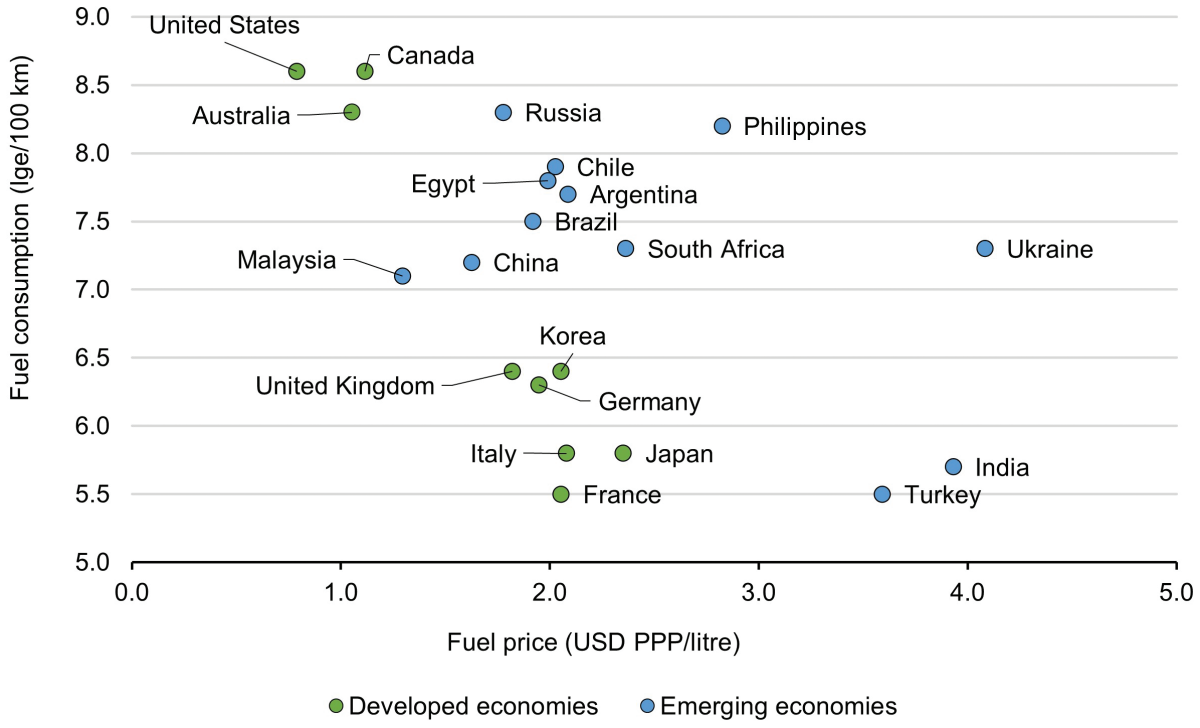
Figure 14 also shows that, if data are analysed separately for developed and emerging economies, fuel efficiency has a tendency to be better in regions with high fuel prices. At a given level of fuel cost, the vehicles sold in leading markets and some of the close followers also tend to be characterised by lower energy use per km than other markets. This reflects a stronger deployment of fuel saving technologies in leading markets and some of the close followers, notwithstanding the effects of differences in vehicle size, weight, footprint and power, in line with considerations that emerged in GFEI analyses (GFEI, 2019).

Ensuring that fuel prices stimulate energy efficiency will require an increasing price on carbon. It is particularly important to have this in emerging economies where purchasing power is increasing and where carbon is not currently priced at all. Many such places can be found in the close followers, aggressive importers and rest of world clusters, and it is important to adapt fuel taxes regularly in these regions to avoid backsliding on fuel economy.

4) Procurement policies

Procurement programs that prioritise zero-emission technologies promote their market growth especially when the market is at an early stage. The best opportunities arise when the government has a say in large vehicle purchase programs, for instance for government agencies or if large government-controlled company renews their vehicles. Such orders incentivise vehicle manufacturers to invest in production facilities and spur the initial deployment of charging points or hydrogen refuelling stations, depending on the chosen technology. Ordering ZEVs and charging/refuelling infrastructure in bulk can reduce costs per unit, because large orders reduce

FIGURE 14: Fuel consumption of cars as a function of gasoline prices (2019)



Source: ITF, 2021, updated with 2019 data and a larger set of countries from IEA, 2021

per-unit transaction costs and reduce risks for manufacturers who scale up production in response.

The public sector also has access to capital at low cost, which can minimise financing costs of these vehicle purchases. These programmes also increase public awareness and visibility for emerging vehicle technologies while they are not yet common.

To maximise benefits and minimise costs, public procurement programmes for zero emission vehicles are best targeted at vehicles with the highest usage levels, as these are the cases where clean technologies offer clear economic advantages. Key examples of these include urban buses, taxis, ride-sourcing and service vehicles (such as garbage trucks), for which public authorities often have regulatory oversight.

Two examples of ZEV procurement policies already in place are:

- The **Clean Vehicles Directive** In Europe which sets minimum requirements – expressed as fractions of the vehicles purchased through procurement contracts and public service contracts – for clean cars, light commercial vehicles, trucks and buses, for 2025 and 2030.

- The **Executive Order on Tackling the Climate Crisis at Home and Abroad** and **The American Jobs Plan** in the United States, which includes explicit instructions to use all available procurement authorities to achieve or facilitate clean and zero-emission vehicles for government fleets at different administrative levels.

Other such policies also exist in China, Korea, Japan and India (ITF, 2021).

Voluntary action from businesses can also reinforce public procurement programmes. This can take the form of advanced market commitments, in which businesses guarantee the purchase of a number of clean vehicles. These commitments may also result in alliances between vehicle operators and manufacturers to design and build vehicles. Examples include:

- Amazon and UPS in logistics, which have ordered large numbers of customized electric vans from vehicle manufacturer start-ups Rivian and Arrival and invested in these companies, respectively (ITF, 2020b).

- Arrival also partnered with Uber for the development of an EV destined to carry passengers (Arrival, 2021).

Following the initial phase of ensuring vehicle and infrastructure supply availability and stimulating vehicle demand, public procurement programmes and voluntary actions from businesses are also crucial for ensuring continued technology cost reductions through technology learning and economies of scale.

5) Economic Incentives

Economic incentives are crucial to scale up the deployment of clean vehicles and the infrastructure they need to have access to energy. They are also well suited to shift consumer choices towards vehicles with better fuel economy, complementing the ZEV contribution to lower emissions from road transport.

Different instruments exist to offer targeted support at successive market stages of the sector's development. Governments that were successful in

TABLE 14: Procurement policies

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
4) Procurement policies	Public procurement supports ZEV production and model diversification at an early market stage. It is best suited fo vehicles with a high usage profile that are subject to public funding, such as electric buses. *Leading markets* and *close followers* tend to adopt these programs first. Leapfrogging opportunities exist for aggressive importers and the rest of the world.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

TABLE 15: Economic incentives

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
5) Economic incentives	Economic incentives support the early deployment of ZEV and the consolidation of their market share. Leading markets and close followers tend to adopt incentives for vehicles and infrastructure first where they also serve industrial development. Incentives are also relevant for aggressive importers, both for new and used vehicles.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

kick-starting a ZEV industry and creating a market for these technologies offer valuable lessons on what instruments work at each market stage. China, Europe (especially the Nordic region) and the United States (in particular California) are the most prominent examples.

Economic incentives can be broadly categorised in two groups:

- Supply-side or "technology push" measures. These are most relevant for advanced technologies, not yet close to market deployment, as they promote investments in R&D and innovation that can later yield cost reductions as well as investments in production facilities.

- Demand-side or "market pull" measures which are better suited to stimulating consumer demand for ZEVs.

The use of these incentives in each of the market groupings considered in this report are considered below.

The extent to which economic incentives are applied differs from market to market, often reflecting local conditions. An overview of economic incentives in use to promote clean vehicle supply and demand in leading markets and close followers is summarised in Table 16 (ITF, 2021) and covers the deployment of ZEVs and their charging infrastructure.

Aggressive importers of clean vehicles are (by definition) in a similar situation as leading markets and close followers, as they developed policies favoring energy efficiency and ZEV uptake, leveraging on the policies that are mobilizing supply developments in leading markets and close followers. The most pro-active countries in these groups tend to be those where there is local vehicle manufacturing capacity, a potential to draw significant economic benefits from a ZEV transition (e.g. due to the endowment with materials that are needed for ZEV manufacturing, like nickel and lithium) and where there is greater awareness of environmental impacts of local pollution.

GFEI work focused on South East Asia and the implementation of the ASEAN fuel economy roadmap (ASEAN, 2019) showed recently that Indonesia, Malaysia, Singapore and Thailand have taken steps to develop differentiated vehicle purchase subsidies and/or taxation, based on environmental performances and including specific treatment for ZEVs. Ambitious policies also exist in Latin America, including in Colombia, Chile, Uruguay, Costa Rica, and Panama. These countries already developed national strategies or plans for electric mobility (UNEP, 2019 and Engelskirchen, 2021).

Other *emerging markets* lag behind on the deployment of economic incentives which would allow them to foster a transition to clean vehicles and clean energy. International support may support them to scale up efforts and to protect from risks of becoming a dumping ground for polluting technologies.

6) Regulatory limits

Regulatory requirements have been crucial in ensuring that fuel-saving technologies increased fuel economy rather than vehicle performance. They are also essential to spur adoption of ZEV technologies once costs have started to reduce, setting vehicle markets on a path to reach decarbonisation objectives. Again, these are considered by country grouping below. Governments in leading markets (including Europe, Korea, Japan and North America) and close

TABLE 16: Economic incentives for clean vehicle supply and demand, focusing on leading markets and close followers.

MARKETS	ECONOMIC INCENTIVES
China	A long series (more than a decade) of economic incentives have been set up on the demand of "new energy vehicles" (in particular BEVs and PHEVs, but also FCEVs) and their supply (along with the supply of key components, such as batteries). Greatest accent on the deployment of publicly accessible charging infrastructure, so far.
Europe	Important series of policy decisions on economic incentives, especialy for EVs (BEVs and PHEVs), many of which are not uniformly occurring at the supra-national scale. There is scope for greater coherence and more effective action, also in the case of infrastructure deployment. This reflects a greater degree of autonomy of each government on topics requiring specific budgetary allocations in comparison with regulatory requirements, which apply across the whole economic area.
Japan and Korea	Growing attention to economic incentives and budgetary allocations to support export capacity, both for vehicles and key components (like batteries), due to limited domestic market size and presence of major global exporters of transport vehicles. Potential limitations in the availability of low-carbon electricity supply, leading to a stronger interest in FCEVs.
United States	Use of economic instruments for research, development and manufacturing of clean vehicles and related energy infrastructure, sometimes with heterogeneous choices across States. Recent decisions focus on scaling up EV manufacturing (BEV and PEHV), battery production, battery material supply chains and cahrging infrastructure deployment, despite a remaining interest in FCEV technologies and other clean vehicle and alternative energy technologies.

followers such as China, have implemented a range of regulatory policies to decarbonize the road vehicles sector. As in the case of economic incentives, they often have a clearly defined scope of application, but are also framed in such a way as to ensure that policy goals are met while taking a life-cycle perspective. They can promote sales of fuel efficient vehicle technologies (including, but not limited to, ZEVs), the expansion of infrastructure to charge or refuel vehicles, and the supply of low-carbon fuels or electricity (Table 18). Regulations on clean vehicles also consider the manufacturing stage, both for the different components and the final assembly. This is especially important In the case of batteries, as already highlighted in the section on technical regulations and standards.

In the light-duty vehicle (**cars and vans**) segment, California, China and Europe adopted regulations that establish specific ZEV requirements and/or

TABLE 17: Regulatory limits

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
6) Regulatory limits	Regulatory limits support the transition beyond early deployment and apply to vehicles as well as charging infrastructure. Leading markets, close followers and aggressive importers tend to implement regulations first. However, they are also important for a resilient technology transition and for keeping out obsolete technologies in rest of the world.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

TABLE 18: Regulatory frameworks for ZEV deployment, infrastructure and energy supply

AREAS OF INTERVENTION	TYPES OF REGULATORY MEASURE
Vehicle	Pollutant emission regulations/standards Fuel economy/GHG emission regulations/standards LEV/ZEV emission mandates Access/registration/use restrictions (and waivers) in portions of the road network Carbon content and sustainability requirements for key components (batteries)
Energy	Carbon intensity and sustainability requirements of energy vectors Charging/refuelling infrastructure deployment requirements

Source: ITF, 2021

incentives. These include California's Zero-Emission Vehicle mandate, China's New Energy Vehicle (NEV) credit mandate, the European Regulation on GHG emission limits for cars and vans. Recently, the Federal government in the United States also moved in this direction, with a proposal to establish more stringent standards beginning with model year 2023 (Federal Register, 2021). The gap between leading markets and other economies in terms of regulatory policies to improve energy efficiency and deploy ZEV and clean energy is wider than in the case of economic incentives. One of the reasons for this gap may be found in the complexity of regulatory texts allowing to measure fuel economy and GHG emissions from road transport vehicles, similar to the ones needed to test pollutant emissions from vehicle tailpipes. For cars and vans, encouraging signs can be spotted in the increased global consensus that followed the adoption and continued update of the Worldwide harmonized Light vehicle Test Procedure (WLTP). Other encouraging signs also come from the fact that, for local pollutants, several emerging economies have followed the footsteps set in leading markets to regulate emissions, despite the complexity of the technical regulations needed to do that. These regulatory texts were even successfully integrated in international trade agreements.

Regulations that prescribe a transition to ZEV in the **heavy-duty** vehicle segment (trucks and buses) are also set to emerge more prominently as battery-electric and fuel cell electric trucks gain a foothold in this market segment. California has adopted the boldest regulation to date. Manufacturers must switch to ZEV trucks and vans from 2024 onwards and the state will only allow ZEV to operate after 2045 (CARB, 2020). All other premium markets (including leading countries and close followers), except Korea, have also established GHG emission regulations for heavy vehicles that encourage a switch to ZEV. On the other hand, there is a lack of international harmonization of fuel economy regulations for heavy vehicles. For instance, existing approaches to the measurement of fuel economy and GHG emissions per km differ even between China, Europe, Japan and the United States. Achieving greater harmonization in this area is important to enable countries with capacity gaps to develop complex technical regulations to adopt regulatory limit values that improve fuel economy and encourage ZEV adoption (ITF, 2020a).

Several markets have set deployment targets for **vehicle chargers and refuelling stations**, yet there is typically no legally binding regulation to support objectives. However, the European Commission recently moved in this direction with the proposal – integrated in the "Fit for 55" policy package – to revise the Alternative Fuels Infrastructure Directive (AFID) of 2014 into a legally binding Regulation. If approved in the following European legislative steps, this would require member states to match the pace of infrastructure roll out with that of ZEV adoption rates prescribed in the block's regulations on CO_2 emission performance standards for cars and vans (EC, 2021b). The Regulation also requires that infrastructure is interoperable and that operators provide transparent user information as well as adequate payment options.

7) Green investment frameworks

Public and private investments are an important driver for the market growth of ZEVs once their technologies mature. Incumbent car manufactures as well as emerging EV start-ups rely on the capital markets for funding R&D activities and the expansion in their ZEV productive capacity. Similar considerations apply to companies supplying low-carbon energy.

TABLE 19: Green investment frameworks

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
7) Green investment frameworks	Green investment frameworks are essential to shift capital flows towards expanding ZEV production and low carbon energy. *Leading markets* and *close followers* are ahead of other markets in the development of these frameworks, as they are home to most investment capital and automotive production capacity.			

Legend

- Most relevant/urgent need for action to stimulate development
- Cases requiring action, but also with greater scope for spill over effects

The market capitalisation of several public companies that focus on ZEV technologies has grown strongly in recent years and the ZEV sector's popularity among private investors is evident. Similar considerations apply to companies that supply decarbonised energy (ITF, 2021). This reflects not only investors' high expectations in the market potential of ZEVs but also an increased interest in green investments that are compatible with international climate objectives. Investments in road transport technologies are subject to special scrutiny due to the sectors large contributions to global GHG emissions.

A clear definition of what technologies qualify as climate compatible can mobilize capital for the ZEV sector (including their energy needs) helps investors aming to restructure their portfolios in this direction. Legal texts clearly defining what can or cannot qualify as clean investment can also be paired with progressively tightened regulatory requirements on the weight of 'clean' options in investment portfolios. This can help limit the scope to fund climate change mitigation compatible projects. The same instruments can also help to steer investments away from what could become stranded assets as decarbonisation policies become more stringent.

Amongst the leading markets, the European Union appears to have made the most progress in terms of defining instruments -such as green bonds - to direct investments towards sustainable projects and activities (see Note 3). Beyond Europe, Korea , Japan and the United States are also starting to develop policies allowing to make progress in this direction (see Note 4).

Development banks and export credit or investment insurance agencies are important players in this area. They must employ a clear definition for green investments to enable technology transfer of ZEV technologies to developing economies, including for example bus fleet conversion projects.

Given the novelty and complexity of these regulations, their application to cases that have a direct relevance for ZEV and clean energy is still at an early stage, and is mainly limited to countries with high degree of political commitment to climate change mitigation and an already strong industrial base. There is therefore the widest gap between leading markets and developing economies where it will be important to strengthen future efforts, in this area. Aggressive importers of clean vehicles have an even stronger case for the adoption of such regulations on sustainable/ green finance.

EMERGING POLICY CHANGES

Whilst there is some established good practice in terms of the policy levers identified above, there are still areas where the challenges to widespread ZLEV adoption whilst clear, are not yet being addressed.

8) Resilient and sustainable supply chains

The growing demand for EVs and the materials required to produce battery systems and electric motors they require comes with both opportunities and challenges.

Opportunities arise in battery and motor production which will in some places lead to the construction

TABLE 20: Resilient and sustainable supply chains

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
8) Resilient and sustainable supply chains	Sustainable supply chains are relevant in all markets due to their cross-border nature. *Leading markets* and *close followers* prioritise regulations and other policy frameworks to drive production towards sustainable prices. Markets with lithium and metal reserves that supply battery manufacturing also need to prioritise policies aiming to guarantee sustainable mining.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

of new manufacturing facilities or the conversion or expansion of existing ones and create economic and employment opportunities. The same is true for raw materials. The demand for battery materials is set to grow dramatically, with demand for lithium for example is set to increase by a factor of 42 between 2020 and 2040 (IEA, 2021).

Challenges include managing existing supply and value chains in the manufacture of vehicle components, and well as the energy ZLEVs use, and the need to ensure that this takes place in a socially and environmentally sustainable way. For example, whilst analyses suggest that long-term shortages of many of battery minerals are unlikely (Olivetti et al., 2017; KPMG, 2021),there is a risk of short-term supply constraints (Benchmark Mineral Intelligence, 2020; Rystad energy, 2021). The COVID-19 pandemic has delayed a number of mining projects, while at the same time accelerating demand for battery electric vehicles due to government stimulus programs (Benchmark Mineral Intelligence, 2020). Ensuring that supply chains are resilient to accommodate increasing material demand is a policy priority.

TABLE 21: Policy actions aiming to build up a resilient, diversified, socially and environmentally sustainable supply chain for battery materials (leading global markets)

MARKETS	POLICIES
China	Aside from its competitiveness and relevance in batteries and battery material supply chains, China released in October 2020 a proposal for battery reuse and recycling management with the objective to optimise resource use. The scope of the proposal includes traceability across the entire battery lifespan (MIIT, 2020).
Europe	In Europe, the proposed regulation on batteries released in December 2020 (addressing sustainability-related aspects) adds to a series of efforts to reinforce its industrial competitiveness on battery manufacturing and critical minerals, as illustrated by the establishment of the European Battery Alliance (in 2017) and Raw Material Alliance (in 2020).
Korea	Korea has also issued in 2020 regulations aiming to facilitate reuse and recycling of used batteries from electric vehicles (Yonhap, 2020) and announced a battery strategy, which covers aspects related with the need to secure material supply, in 2021 (Blue House, 2021).
Japan	Japan's Green Growth Strategy Through Achieving Carbon Neutrality in 2050 also refers to a contribution to the establishment of international rules and standards on storage batteries regarding their carbon footprint, ethical material procurement, and promotion of reuse (METI, 2020). The strategic energy plan of Japan also stressed the importance to secure a stable supply of mineral resources (METI, 2018).
United States	In the United States, the recent Executive Order on America's Supply Chains places greater emphasis on risks related with the availability of critical materials (White House, 2021b).

This is highest in global regions that have policies in place to facilitate a near term transition to ZEV and low-carbon energy, as these are the ones that will have the highest need for it. This includes the premium vehicle markets of the most developed global economies and other large markets that adopted pro-active EV development policies, if they do not already have a strong position, like China. This is consistent with the fact that leading markets and close followers are those that have taken, to date, concrete steps in this direction. These measures, summarised in Table 21, can serve as a blueprint for actions to be taken in other major markets (such as India) and can also offer opportunities to foster economic development in emerging economies with high levels of endowment with materials that are needed for ZEV manufacturing.

Independent voluntary initiatives from the private sector also have significant scope to complement public policies to foster socially and environmentally sustainable supply chain for materials needed in clean vehicles. The Global Battery Alliance (GBA), a public-private collaboration platform of 70 organizations founded in 2017 to help establish a sustainable battery value chain, gives a relevant example in this content (WEF, 2021). The OECD work on due diligence guidance for Responsible business conduct on mineral supply chains is also a precious resource in this context (OECD, 2021).

9) Taxation reform

Excise taxes on road transport fuels are an important revenue source for many governments. A strong market growth of ZEVs that eventually displaces ICE cars can affect these government revenues and poses policy challenges to the ZEV transition in the long term. Government revenues from electricity taxes will increase along the market growth of ZEVs, but not at a rate that compensates cuts in fuel tax revenues. This is because taxes for electricity are usually lower than for diesel or gasoline per energy unit (and bound to remain lower, if electricity generation is decarbonised, in the future) and because ZEVs consume less energy overall than ICE cars due to their high energy efficiency.

A full transition to ZEV sales by 2035, in alignment with the UN Climate Action Pathways targets for leading markets, comes with a cut of average taxation revenues per vehicle of roughly 45 % in 2035 and in markets that tax electricity at similar rates as fuels. Revenues will continue to decline after the target year (up to 80%, in 2050) as existing ICE cars reach the end of their lifetime. In markets where the end of ICE sales is envisaged at a later stage, the revenues will decline more gradually, with a drop up to 45% by the target year if electricity taxes are the same (per unit energy) as those on liquid fuels.

Road user charges are a policy solution that offers the possibility to make up for lost fuel-duty revenues and adequately price the use of vehicles. Opting for this solution would effectively switch the tax base to distance travelled rather than energy use (OECD, 2019a). Distance-based charges help to fit the 'polluter pays' principle, whilst location-specific and time-dependent distance-based charges could provide a cost-effective way to address congestion, whose costs are particularly high in urban areas and at certain times of day. Addressing congestion emerges as a policy priority especially in markets such as the aggressive importers and rest of world., where the number of vehicles is set to soar. In addition to reduced GHG emissions, less air pollution and less congestion, shifting to distance-based

TABLE 22: Taxation reform

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
9) Taxation reforms	Important to ensure the economic viability of the ZEV transition that can impact fuel taxation revenues in the long term. Policy responses such as road user chargers rely on rolling out enabling technologies and become first a priority in *leading markets* and *close followers*, which reach a high ZEV market share before other markets.			

Legend

- Most relevant/urgent need for action to stimulate development
- Cases requiring action, but also with greater scope for spill over effects

TABLE 23: Workforce support

	LEADING MARKETS	CLOSE FOLLOWERS	AGGRESSIVE IMPORTERS	REST OF THE WORLD
10) Workforce support	Supporting the social sustainability of the technology transitions (towards electrification, automation and digitalization) is most relevant for countries with strong automotive industry, which are leading markets and close followers. Transport electrification with a shift away from fossil fuels will eventually affect the energy sector in all markets.			

Legend

Most relevant/urgent need for action to stimulate development

Cases requiring action, but also with greater scope for spill over effects

charges can also help to address other negative environmental and social externalities of road transport, in particular noise and traffic incidents (OECD, 2019b). Since electric vehicles have fewer negative externalities than conventional vehicles, user charges should be lower than for conventional vehicles.

A shift to road user charges is likely to be complex, since governments need to find the balance between stimulating innovation and the technology transition, while also addressing the issue of revenue shortfalls, the social impact of road-charging, and the impacts on road transport behaviour. Road user charges need to avoid increases in vehicle use of EVs, while maintaining incentives to switch to them Recent announcements in the United Kingdom (UK Parliament, 2020) and the Netherlands (Dutch Government, 2020) confirm the need for governments to begin to develop long-term policies to manage the transition to ZEV and that awareness for this needs increases.

10) Workforce support

Economies with large automotive sectors will see structural changes to their industry and labour sectors as the transition to ZEVs proceeds. The switch away from internal combustion engines transforms the needed labour skill sets, not only in the engine manufacturing stage, but also for vehicle maintenance and the supply chains for vehicle and fuel/energy production. Governments and car manufacturers have a role to play in providing training opportunities that prepare workers for the transition to ZEVs. Governments and industry must also ensure that a country's automotive sector remains competitive to avoid disruptions to the economy and the labour market. Other implications of structural change in product demand (e.g. fossil fuels), infrastructure developments and related supply chains fall on other sectors, including energy and logistics (ITF, 2021).

Timely re-training of workers for sectors and technologies for which demand is expected to increase in the future is essential. These are likely to include skills required by the digital transitions, such as data analysts and scientists, process automation specialists and industrial and production engineers. Continuing education, training and lifelong learning are expected to become increasingly important for workers trying to secure employment in the automotive industry, or in other sectors (ILO, 2021). Career guidance can complement this by helping adults successfully navigate a constantly evolving labour market through advice and information on job and training opportunities (OECD, 2021a).

Policies also need to encourage employers to invest in training, as the scale of the challenge goes beyond the capabilities of the public sector alone (OECD, 2021b). Large automotive companies have an established set of measures designed to develop the skills of their workers all over the world, but more is required to address the deep transformation that the sector faces. Investments in the capabilities of a workforce that will master new technologies and possess the right skill set to drive innovation, productivity and sustainability in the future are crucial (ILO, 2021).

NOTES

1. This proposal includes progressive requirements to minimise the carbon footprint of EV batteries, as well as a number of other requirements: increased safety; increased transparency and use of recycled content; minimum electrochemical performance and durability performances; supply chain due diligence obligations; specific material recovery targets; repurposing and remanufacturing for a second life. A battery management system also aims to store the information and data needed to determine the state of health and expected lifetime; and a battery passport (i.e. electronic record) aims to track each industrial battery and EV battery placed on the market or put into service. The proposal also envisages the development of minimum mandatory green public procurement criteria or targets.

2. The designs and timelines of these regulations differ, yet all will promote ZEVs to be a leading technology in the LDV market. California's Zero-Emission Vehicle mandate will forbid sales of non-ZEV cars from 2035 onwards (Office of Governor, 2020). China's New Energy Vehicle (NEV) credit mandate is a point-based system that classifies ZEVs according to technical specifications (e.g. electric range, rated power and fuel economy). It sets a NEV credit target of 18% for 2023 (IEA, 2020). The European regulation requires improvements of the average fuel economy of new vehicle sales of 37.5% for cars and 31% for vans between 2020 and 2030. A proposal to tighten this to 55% for cars and 50% for vans relative to a 2021 benchmark based on the Worldwide Harmonised Light-duty Vehicles Test Procedures (WLTP) was included in the "Fit for 55" policy package presented in July 2021. This also adds a requirement for a full transition to vehicles with zero CO_2 tailpipe emissions by 2035 (EC, 2021a). The US proposal to tighten fuel economy standards is accompanied by a 50% ZEV goal for 2030 (Shepardson and Mason, 2021).

3. The 2020 Taxonomy Regulation's classification for sustainable economic activities include cars with up to 50 g CO_2/km of tailpipe emissions (therefore including PHEVs) until 2025, and zero tailpipe emissions of CO_2 after that (therefore excluding PHEVs). They also include buses, two-wheelers, three-wheelers and LCVs with zero tailpipe emissions of CO_2 and heavy trucks that emit less than half of the average CO_2 emissions/km of all vehicles in the same vehicle category (EC, 2021c). Infrastructure dedicated to the operation of vehicles with zero tailpipe CO_2 emissions are also eligible and include electric charging points, electricity grid connection upgrades, hydrogen fuelling stations and electric road systems (ERSs) for private vehicles or public passenger transport (EC, 2021c). The proposed framework also defines sustainability thresholds for fuel production.

4. Korea plans to build up a taxonomy for green finance to channel financial flows into businesses delivering environmental benefits (UNFCCC, 2020). The Japanese government has announced it will take measures to attract private investment into green, transition and innovation initiatives, while formulating basic principles and roadmaps for industries with large CO_2 emissions (METI, 2020). The United States Treasury is also supporting international efforts to better identify climate-aligned investments and to encourage financial institutions to credibly align their portfolios and strategies with the objectives of the Paris Agreement (Shalal et al., 2021).

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