Reducing passenger vehicle emissions

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AUTHORS
Andrzej Ancygier, Olivia Waterton, Sepideh Rabiee.

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Passenger Cars

Emissions standards

In the EU member states, emissions standards are adopted at the EU level. The EU Regulation 2019/631 from 2019 aims to tighten emissions standards (in gCO₂/kilometre) from new passenger cars by 37.5% in 2030 compared to 2021 levels (Regulation (EU) 2019/631 of the European Parliament and of the Council, 2019). The proposal tabled in the “Fit for 55” framework strengthened this emissions reduction goal to 55% and introduced a new goal of emissions reduction by 100% in 2035 (Proposal for a Regulation of the European Parliament and of the Council Amending Regulation (EU) 2019/631, 2019).

There are a few shortcomings in the current EU Regulation 2019/631 and the “Fit for 55” framework. In both policies, the proposed emissions reductions correspond to new cars sales each year. The average EU car age is 11.5 years, and Eastern European cars are on average even older. The proposals, which focus on new cars, will therefore result in delayed emissions reductions. Additionally, the emissions rate in both policies refers to the average emissions among a manufacturer sold car fleet. Manufacturers can sell much more emissions-intensive vehicles, while selling cleaner vehicles elsewhere.

Member states may accelerate the decarbonization of their car fleet by closely linking the annual taxation of vehicles with their emissions. Since 1 January 2021, CO₂ emissions have become more influential in the German KFZ tax system.

The European Commission is proposing a Euro 7 standard in order to close the gap between current standards and the 2035 deadline for internal combustion engines phase-out. When Euro 7 comes into effect in 2025, an estimated 100 million diesel and gasoline cars sold in Europe will face legal limits on emissions. Estimates by a consortium of independent experts show that these cars will only cost 100 to 500 EUR more than current models and will come with the co-benefit of emitting much less NOx and particle emissions than current Euro 6 models.

Since Western European cars have an average road life of 11 years and cars in South-eastern European Member States last on average more than 15 years, the Commission expects Euro 7 models to be in circulation up to 2050. Thus, the Euro 7 standard is necessary for the EU to hit its net-zero emissions target. The Euro 7 standard is especially important especially in countries with a sizable imported second-hand car market. The Commission has intended to develop a standard like Euro 7 by the end of 2022.
According to an IEA estimate from November 2021, the average rated fuel consumption on new light-duty vehicles fell only by 0.9% between 2017 and 2019 – far less than the 1.8% annual decrease between 2010 and 2015. On a global average, in 2019, a new light-duty car consumed 7.1 litres per 100 kilometres. New cars sold in 2019 were, on average, 6.2% heavier (IEA, 2021). This increased weight can explain the slight reduction in average fuel consumption.

**Low Emission Zones (LEZs)**

Low-emission Zones (LEZs) may be an attractive tool to reduce air pollution in some parts of a city, e.g., city centres. LEZs would reduce CO₂ emissions and promote the transition to using more fuel-efficient and zero-emissions vehicles. There are two main variations of LEZs: (1) areas where the highest-emitting vehicles may not travel, and (2) areas in which all vehicles, or vehicles above certain emissions limits, must pay a fee to enter.

While LEZs may be very effective in reducing air pollution and CO₂ emissions, fees from LEZs may have a high political cost if introduced on short notice. To increase the acceptability of LEZs, Policymakers should announce them well in advance. Any increase in coverage and charges should be slow and steady. Governments should use the space gained from a reduced number of cars to benefit most of the citizens living in LEZs. Governments should also develop attractive alternatives to private vehicles, like public transport, walking and cycling.

If policymakers introduce congestion charging and parking fees together, they can significantly impact passenger car activity levels. Local circumstances will determine the optimal balance. If policymakers rely overly, or exclusively, on parking fees, ride-share drivers or future autonomous vehicles will move constantly throughout a city (Gindrat, 2019). If the cost of burning fuel by driving is lower than the cost of parking, parking fees may be counterproductive (Gindrat, 2019).

**LEZ examples**

London’s well-known Low Emission Zone and Ultra Low Emission Zone (ULEZ) bans high emissions vehicles from the inner city 24 hours a day, seven days a week, except Christmas. Cars allowed to drive in the zones are charged 12.50 GBP (14.32 EUR) a day for cars, vans and motorcycles, and 100 GBP (114.57 EUR) a day for lorries, buses and coaches. The ULEZ resulted in a 20% reduction in emissions and dropped the worst polluting vehicles entering the zone each day from 35,578 to 23,054. Mayor Sadiq Kahn recently announced plans to expand the ULEZ to cover the entire greater London area by 2023, estimating an additional 20-40,000 high-emissions cars to be taken off the road (Topham, 2022).

Brussels, Belgium introduced a LEZ for the Brussels-Capital region, banning the most polluting cars stepwise, based on fuel type and EURO standards. The LEZ concerns cars, vans and (mini)buses and coaches. The LEZ will ban diesel cars, diesel hybrid cars, and vans from travelling within the LEZ as of 2029. The LEZ will accept most
petrol/hybrid/CNG/LNG cars and vans Euro 4 and above in the LEZ until 2029; Euro 6d will be permitted until 2034. The region sets a fine of 350 EUR for failure to comply with the regulation. Based on vehicle license plates, police will carry out checks through fixed and mobile cameras (Low Emission Zone, 2022).

Spain implemented a law in 2020 introducing LEZs in all municipalities with a population greater than 50,000.

In 2019 Krakow, Poland, became the first Polish city to implement a LEZ.

Area bans

Similarly to congestion charging, area bans can be useful when it comes to decreasing emissions from passenger transport. Typically, area bans limit private vehicle travel through some geographic area and often repurpose roads for public purposes; this could include expanding bike lanes and pedestrian walkways, adding outdoor seating or play space for children, and increasing public green space by adding trees and planters in areas which otherwise would've been taken up by cars.

There are several types of area bans, including:

- car free zones – typically entire city centres or other congested areas;
- smaller car-free blocks, typically around areas with high numbers of pedestrians or which are not suited to car travel, and
- areas closed to through traffic.

Popular support for area bans has grown over the past several years, and many larger cities are experimenting with banning cars from specific streets or on certain days as a precursor to implementing a total area ban.

Area ban examples

Paris, France is introducing a plan to ban all combustion engine cars from its roads by 2030 as part of a bid to reduce greenhouse gas emissions (Goebel, 2017). While a ban on diesel cars had been already announced, with implementation beginning in 2024, a representative from the Mayor's Office said that by 2030 the ban would include both petrol and diesel cars. Electric vehicles would not be impacted by this ban.

La Cumbrecita, Argentina is a hamlet about 120 km away from the capital, Cordoba, in which no cars are allowed to enter. In 1996 the town and surrounding area were declared a protected environment zone, and the La Cumbrecita was deigned a "pedestrian town" (La Cumbrecita, 2022). Visitors are encouraged to plan their stays in advance as outside vehicles are not allowed in and only authorised vehicles may be used within the area. The regulations on vehicle usage are stringent, with the express purpose of protecting the environment.

One of the most well-known cities with a car-ban in place is Venice, Italy. Due to the city's narrow passageways and many canals, vehicles never became a popular or
practical mode of transport in the city centre and it continues to remain this way (Pasiakou, 2017). Locals and visitors must walk, bike ride, or take water transport to navigate the city.

Subsidies for EVs

Subsidies for purchasing electric passenger cars have recently become a prominent way to promote electric mobility and reduce passenger car emissions. Some EU countries have offered subsidies as high as 9,000 EUR.

EV subsidies make phasing out combustion cars possible by giving EVs necessary economies of scale. According to the recent European Commission decision, the sale of new combustion cars should stop in 2035 (Proposal for a Regulation of the European Parliament and of the Council Amending Regulation (EU) 2019/631, 2021). This goal is only possible if zero-carbon alternatives at a similar price are available (Transport & Environment, 2021). Additionally, since the cost of electric vehicles exceeds the level of the subsidies by a factor of three or four, financial assistance will trigger investment of significant private capital into zero-carbon alternatives.

At the same time, EV subsidies have several controversies. New electric cars are mainly affordable for higher-income households, raising significant equity concerns. In most EU countries, car buyers can also use the subsidies for plug-in hybrid electric cars. These cars have a minimal range. In many cases, such vehicles are never or only sporadically charged electrically. As a result, these policies, ostensibly to promote electric mobility, effectively subsidise new combustion vehicles.

Replacing combustion cars with electric ones does not solve car congestion and public space misappropriation. Programmes which promote vehicle ownership should be considered in concert with policies which strengthen alternate modes of transport. EVs may worsen these problems because of their lower operating cost.

Governments can promote electric cars better in numerous ways, such as:

- **A bonus-malus tax system** would impose additional taxes and fees on combustion vehicles. The government would spend the collected funds to promote electric cars and public charging infrastructure. The additional tax could apply especially to the registration fee of imported or new combustion cars. This version of the tax would reduce the financial burden on the public and increase the measure’s acceptance.

- **Steady and predictable decrease of the subsidy after a certain number of electric cars has been sold.** If the sale of EVs increases significantly, high subsidies may be unsustainable, which may require sudden changes. A predictable mechanism to reduce the subsidy’s financial burden would be to decrease the level of subsidy by X% after X number of cars have been sold. It
could also accelerate electric mobility, since customers will want to benefit from higher initial subsidies.

- **Increased subsidies for buyers purchasing a car with a car scrappage scheme.** Scrappage would help to avoid a situation in which older, more carbon-intensive cars are still on the street even after the sales of electric vehicles increase.

**Support for electric plug-ins should be significantly limited** and conditional on drivers mainly using the “electric mode”. Linking the subsidy to a share of kilometres travelled electrically in a specific period creates an incentive to develop EVs with larger ranges and charging modes. This incentive may alleviate concerns for those worried about the range and charging possibilities.

There are other ways to promote EVs, such as tax breaks for owners (registration, ownership), exemptions for parking fees in cities, or the possibility to use bus lanes. Policy makers must make these policies temporary and avoid additional problems (e.g., blockage of bus lanes, loss of tax proceeds) if people switch most or all combustion cars to EVs. Ensuring that policies are temporary, and communicating this temporariness, could facilitate EV use. Potential buyers would switch quickly to take advantage of these incentives.

**Hydrogen**

Hydrogen, compared to electric vehicles, will remain a debate-filled alternative based on enduring cost-competitiveness and feasibility questions (van Vliet et al., 2011). The Canadian Hydrogen and Fuel Cell Association estimates that hydrogen vehicles may have a considerably lower carbon footprint compared to BEVs. FCEVs have an average footprint of 2.7g/km versus 20.9g/km for BEV on average (Canada Hydrogen and Fuel Cell Association, 2022). According to the International Council on Clean Transportation, hydrogen fuel cell vehicles benefits including increased energy efficiency, quick refuelling time, increased renewable energy use, and reduced greenhouse gas emissions (Moultak et al., 2017). A recent study by Ueckerdt et al. (2021) found that the mitigation costs of hydrogen range between 800-1200 EUR/tCO₂ (Ueckerdt et al., 2021). However, they suggest that large-scale deployment of the technology could bring down costs to 20-270 EUR/tCO₂ by 2050 if certain highly unlikely conditions are met.

Hydrogen cars have four advantages for passenger transport:

- **Charging:** Hydrogen fuel cell power charges faster than battery-powered electric vehicles and at a similar time to conventional ICE vehicles. Hydrogen fuel cells vehicles should have a charging time under five minutes.
- **Range:** Hydrogen fuel cell cars now have an average range beyond 500 km. The average range of full electric vehicles was about 318 km in 2021. A few electric vehicles, such as the Tesla Model S, can have a range up to 373 miles. The EV Database shows that one can choose a range from 95 to 640 km (EV Database, 2022).
• **Performance**: Electric motors of hydrogen and battery electric cars produce a maximum torque instantly (i.e., maximum twisting force that an engine can generate) and possess strong low-speed performance.

• **Price**: The price for fuel-cell cars remains high compared to ICE engines. However, that price has declined substantially. Although FCEVs remain more expensive per 100 km than BEVs and ICE vehicles, the total cost of ownership will halve over the next ten years according to a Deloitte Report (Deloitte China & Ballard, 2020). In the meantime, the price of battery electric cars will be competitive with the price of ICE cars.

The market and the charging infrastructure of battery electric cars are more advanced in Europe. It is more valuable to invest public money in encouraging BEVs use than hydrogen car use. Hydrogen is likely to be more suited to future air and rail applications.

**Biofuels**

Biofuels are a tricky strategy for reducing road transport emissions. Emissions intensity from conventional and advanced biofuels depends on correct carbon accounting and a sustainable supply. The experience of the ILUC reform, and the EC’s 2016 Globiom report, found that most conventional biofuels, especially biodiesel, were more emissions-intensive than traditional fuels (Bauen et al., 2015; Casinge, 2015). Most conventional biofuels are more emissions intensive than traditional fuels because of the Renewable Energy Directive, which neglects indirect land-use change as an emissions factor in life-cycle assessment calculations for agrofuel emissions.

The discussion around 2030 policies will focus on limiting biofuels’ role in decarbonising European transport. While conventional biofuels have proved to not be a viable option due to their high emissions, contribution to biodiversity loss, and potential for fuel vs food conflict, advanced biofuels are slow to come to market. The absence of a clear definition of “waste”, which allows for unsustainable raw materials that can increase emissions, has hampered the development of advanced biofuels (Mestre, 2021).

Currently, a further revision of the RED should phase out high emitting biofuels, such as those made from imported soy from South American countries. Soy from this region is a high-ILUC crop linked to deforestation. A revision of the RED should also consider strengthening sustainability safeguards for the eligible feedstocks for advanced biofuels in Annex IX. Annex IX considers UCO and other feedstocks in terms of emissions and other negative impacts.

Imports of UCO and HVO made from it should be banned, because the oil that is truly only from gathering is difficult to separate from oil that is produced by adding little used oil to fresh palm oil. Member states should shy away from biofuel blending targets for road transport. **Electrification of passenger cars offers a much more viable option. Biofuels are more relevant, if anywhere, for other modes of transport.**
Eco-driving

Eco-driving reduces emissions by taking specific steps to increase efficiency and adapt the vehicle to driving conditions to minimise pollution and congestion. Promoting eco-driving in vehicle traffic is a relatively low-cost measure to reduce carbon emissions and fuel consumption (Barkenbus, 2010).

Eco-driving centres on maximising fuel under certain road and traffic conditions by changing practices around acceleration/deceleration, speed, idling time, and route choice (Huang et al., 2018). Drivers should generally reduce speeds to the most efficient for their vehicle, maintain constant speeds by anticipating high traffic situations, and minimise abrupt acceleration or braking (Caban et al., 2019). Instructors can teach these driving style changes at all levels.

There are different methods for reinforcement, ranging from courses to real-time technological feedback. In the first option, as part of licensing or re-certification, drivers can take a specific course which teaches them how to anticipate traffic, change gear economically, select the most efficient routes, and become aware of maintenance issues which impact fuel economy (NC Clean Energy Technology Center, 2015). Vehicle efficiency and the associated variables may change with time. These changes, along with human error, will require instructors to repeat these courses for maximum efficacy.

The second reinforcement option takes advantage of eco-driving devices, which measure fuel economy and highlight the most efficient speed or when to change gears (Boriboonsomsin et al., 2010). These devices have been shown to impact how people drive and benefit from addressing driving behaviours as they occur. Eco-driving devices and real-time feedback have been estimated to improve fuel economy, decrease emissions by 10-12% per trip, improve road safety, and decrease noise pollution. Estimates found that while 40% of drivers already practise eco-driving techniques, 95% of drivers could use them if gas prices surge. A recent IEA report on emergency measures to cut global oil demand suggests that applying eco-driving principles to passenger transport and goods delivery could save an estimated 320 thousand barrels of oil per day, or around 0.3% of global oil demand (Boriboonsomsin et al., 2010; Caban et al., 2019; IEA, 2022).

**Eco-driving examples**

In the private sector, The International Road Transport Union (IRU) offers eco-driving training courses for corporate clients (e.g. those corporate driving cars or fleet vehicles) which wish to maximise fuel efficiency and decrease emissions. In the course, drivers learn optimal use of vehicle technology, look at the effects of their driving behaviour, and learn how to monitor and evaluate road conditions to maximise efficiency. Onboard monitoring software then measures driving habits and changes in fuel economy over time (International Road Transport Union, 2022).
Speed limits

Speed limits can increase safety for all road users and improve fuel efficiency. However, the impacts on emissions reductions differ depending on whether the speed limits are applied in populated areas or motorways.

**Speed limits on motorways**

Speed limits on motorways have a significant impact on CO\(_2\) emissions. Carbon dioxide output is directly related to fuel consumption. Therefore, increasing fuel efficiency and reducing consumption is critical to reducing vehicle carbon emissions. Recent White Papers by the European Commission and strategies from the European Environment Agency encourage lowering speed limits to cut fuel consumption and transport emissions (*Mobility and Transport*, n.d.). Lower speed limits could potentially have an immediate impact on emissions. A simulation found that cutting motorway speed limits from 120 to 110 kph could save current technology passenger cars 12-18% on fuel, assuming smooth driving. The simulation shows that fuel consumption generally decreases with reduced speed (European Environment Agency, n.d.). Regulators can find an optimum balance when lowering motorway speed limits between mobility, safety, and environmental concerns. This balance can protect drivers, passengers, and the environment. 75% of European drivers could accept lower speed limits mainly because of the reduction in emissions (Data Europa EU, 2015).

EU’s Regulation 2019/2144 requires car manufacturers to install Intelligent Speed Assistant (ISA) after 6 July 2022 in new cars to increase compliance with speed limits (EU) 2019/2144, 2019; Piątek, 2021). The Intelligent Speed Assistance is an electronic speed limiter designed to inform drivers of the speed limit, prompting them to slow down if they speed.

Russia’s invasion of Ukraine bolstered momentum for lowering motorway speed limits. This momentum was especially strong in countries without a motorway speed limit. In March 2022, Germany’s *Umweltbundesamt* announced a series of recommendations for reducing fuel demand. Under reasonably conservative assumptions, the *Umweltbundesamt* found that reducing top speed to 100kph on main motorways and 80 kph on roads outside of towns would save the German public 2.1 billion litres of fuel annually. This estimate even accounts for drivers who do not follow the speed limit. This change would save 4% of all fuel consumed by the transport sector annually and could reduce emissions by 5.3 million CO\(_2\) tonne-equivalent (Stoll, 2022).

**Speed limits in residential areas**

Speed limits in residential areas have a much lower impact on emissions. According to some assessments, the lowest emissions occur between 55-80 kph. However, if the car isn't alone on an empty straight road without intersections, the consumption will increase, and speed limits as low as 30 kph have a significant impact on the safety of drivers and even more so for cyclists and pedestrians. For example, Helsinki introduced in May 2019 a 30 kph speed limit on all roads in residential areas. As a result, no pedestrians or cyclists died in traffic accidents by the year’s end (Samaras, 2012).
Several cities introduced speed limits of 30kph, usually starting from city centres and expanding its scope to the whole cities. In 2021, the European Parliament adopted the resolution on EU road safety based on the Stockholm Declaration. The resolution lowers speed limits in residential areas and areas with many cyclists and pedestrians to 30 kph across the EU (Gressai et al., 2021).

Pollution and health implications
The World Health Organization recently recognised noise pollution as one of the main negative implications of modern life, right behind air pollution. Noise above 55 dB(A) at night can seriously reduce the quality of sleep and correlates with an increased risk of heart disease (Data and Statistics, n.d.). One of the primary sources of noise pollution is road traffic. Around 40% of EU citizens experience road noise levels above 55 dB(A) during the day and at night.

The key factors impacting road noise are speed, engine type, and road type. Road type cannot often be controlled for (Camea, n.d.). Above certain speeds, engine type becomes immaterial (Speed limits, 2022). Therefore, careful speed management remains the critical factor when reducing noise pollution (ibid.). A 2016 study found that road noise increased between 1.5-3 dB(A) for every 10 kph speed increase (An & Ohm, 2016). Policymakers should lower speed limits, and thus reduce noise pollution, to a level compatible with health and safety requirements. This reduction is particularly important at night. Lower speed limits' improved safety and decreased noise pollution are the main reasons for their popularity (Dinh & Kubota, 2013).

Speed limit examples
In 2015 Katowice, Poland, introduced the Tempo30 zone in the city centre and extended the zone to more than a dozen areas. Tempo 30 extended into more city centre streets in 2019, as part of European Sustainable Transport Week. Data from 2014 and 2018 reveal concrete benefits. Accidents decreased by 41%, while accidents involving pedestrians and cyclists fell by approximately 37% (Strefa Tempo 30, n.d.). Expanded cycling infrastructure and the reprogramming of traffic lights to the “all red” mode complemented the Tempo30 zone (Wprowadzenie strefy tempo 30 w Katowicach przynosi efekty. Na drogach jest coraz bezpieczniejszej, 2019).

Grenoble, France, a city of 160,000 inhabitants and 14 surrounding municipalities, introduced a 30 kph speed limit on 1 January 2016. The speed limit is part of the “Calmer City” initiative, which aims to distribute public space between travellers using different ways equitably. Grenoble simultaneously created a new priority cycling network. Lille introduced a 30 kph speed limit in August 2020, Brussels introduced a general 30 kph speed limit on January 1, 2021, and Paris introduced one in August 2022. Paris has additionally significantly increased the number of speed cameras to ensure enforcement (Other 30 Cities, 2021).

Bilbao restricted 87% of its streets to 30 kph in summer 2018 and expanded this restriction across the city by 2020. As of May 2021, the maximum speed limit on most Spanish roads is 30 kph. This speed limit applies to all single or two-lane roads within
built-up areas. Recent increases in urban walking, cycling and electric scooter use inspired this change (Dragonetti, 2020).

Zurich mainly lowered speed limits to reduce noise pollution. Zurich 2010-2012 pilot project introduced a night-time speed limit. The Swiss government is negotiating speed limits of 50 and 30 kph nationwide, but Zurich has already introduced a daytime 30 kph limit on 400 kilometres of road network (Driving in Switzerland, n.d.).

Improving procurement procedures

Climate action is especially efficient when targeting government procurements. Governments, such as public administration, police cars, fire brigades and more, purchase a significant share of passenger cars. Public authorities often use these vehicles much more often than private cars. The more extensive fleet allows for economies of scale for charging infrastructure. However, path dependencies limit government procurement improvements. Those responsible for renewing the fleets often lack critical knowledge about the opportunities low carbon alternatives offer. Second, governments typically calculate vehicle purchases and refuelling on separate budgets. Governments miss opportunities for much lower operating costs by electrifying their car fleet, which may have higher upfront costs.

Targeted training aimed at educating procurement experts could enhance their awareness about state-of-the-art developments in non-combustion vehicles and increase their self-confidence in advocating for purchasing new kinds of cars (e.g. EVs).

The training should include:

- an update on the technical and economic feasibility of clean vehicles;
- list of potential sellers and models;
- preparing drafts of calls for bids;
- sessions with the providers of the necessary infrastructure, and
- sessions with the providers of the required funding (e.g., EVs, charging infrastructure) (Romjue, 2021; What Is Electric Vehicle Fleet Management?, 2021).

The training should target:

- Fleet managers and fleet engineers in the public sector at the municipal and state level.
- Members of the public administrations responsible for budgeting.
- Department managers for fleet users.

Targeting both upper- and mid-level management can ensure that fleet electrification has the necessary administrative support at all levels and that all fleet stakeholders support the transition (Efficient Public Sector Fleet Operations, 2007).
The United Kingdom's Department for Transport (DfT) created the “Freight Best Practice programme”, supplying free training materials, briefs, and reports to managers and associated workers in logistics, particularly those working on fleet efficiency (Freight Best Practice, 2007). A cornerstone of this project was reducing emissions in private and public sector fleet vehicles. At its peak, the programme provided 200,000 informational guides, best practice briefs, and case studies to fleet managers and drivers around the UK ([ARCHIVED CONTENT] Freight Best Practice | Business Link, 2011).

Tampering Prevention

Without regular maintenance, motor vehicle emissions, especially NOₓ and CO₂, increase significantly over time. Used cars without a complete maintenance history tend to have much lower market prices. As a result, some drivers use them, despite their much higher fuel costs resulting from low engine efficiency. In some cases, intentional tampering can also be a cause of increased emissions.

To reduce the number of non-roadworthy cars, governments should conduct regular roadworthiness tests based on legislated criteria. In addition, ad hoc technical roadside checks, especially in rural areas, should be more frequent to discourage utilisation of overly polluting vehicles.

Tampering prevention examples

In 2004, Belgium required sellers of second-hand cars to give new car owners a “Car-Pass” document and certificate. The certificate would ensure that nothing tampered with the value given by the odometer. Belgium updated the law in 2018, giving the “Car-Pass” certificate more information such as CO₂ emissions, vehicle inspections and recalls. Car-Pass also required that CO₂ emissions on the Car-Pass comply with a certificate of conformity. Each time a car is taken to a garage, a workshop or a vehicle inspection, the current mileage is added to Car-Pass’s database (About Car-Pass, n.d.).

South Korea has strong emissions and testing requirements. Every private vehicle must be tested at least every two years, and vans and light trucks must be tested every year. Failure to comply results in increasing fines. South Korea’s tests are comprehensive. Approved garages and testing centres check such things as steering, speedometer accuracy, braking power, noise levels produced, emissions under different circumstances, wear on the tires, frame, and body of the car, as well as other factors which may impact the roadworthiness and efficient functioning of the vehicle (Korea Environment Corporation, 2017).

Electric two-wheeled vehicles
Emissions standards for motorcycles are much laxer than passenger cars. This oversight almost entirely ignores the emissions reduction potential for this transportation mode. Whereas Regulation (EU) 168/2013 introduced Euro 5 standard for new types of approval starting in 2020, there is no explicit requirement to reduce the CO$_2$ emissions in the following years (EU 168/2013, 2016).

In addition to high CO$_2$ emissions, motorcycles can produce significant amounts of other air pollutants, especially high-level emissions of carbon monoxide and nitrogen oxides (Edelstein, 2016). Motorcycles are one of the primary sources of noise pollution in urban areas (Edelstein, 2016). Because motorcycles mainly serve as entertainment, they are clear contenders for electrification incentives and targeted bans to reduce vehicle emissions (Sugue, 2021).

However, the loyal following around traditional motorcycles challenges transitioning from them. Up to 45% of riders, according to recent polling by the Federation of European Motorcyclists’ Associations, would switch to alternative transportation rather than purchase a newer zero-emissions or electric motorcycle (Taal, 2021). The costs of e- and zero-emissions motorcycles also present a challenge, since 89% of respondents said they would refuse to pay more for one than for a classic motorcycle. E-motorbike costs remain stubbornly high. Zero, a US-based start-up manufacturing only e-bikes, charges around 16,000 EUR for a bike, and a Harley-Davidson e-motorcycle will run north of 30,000 EUR—incredibly expensive compared to traditional motorcycles (LiveWire Motorrad | Harley-Davidson Deutschland, n.d.)

Policymakers could incentivize switching from standard motorcycles to either other forms of transport or e-motorcycles. One of the most common forms of incentive is a rebate, which has been proposed in Washington state in the United States, who’s legislature proposed a USD 1,000 rebate (964 EUR) for the purchase of zero-emission or e-Motorcycles, in conjunction with federal rebates which are already in place (Stiffler, 2022). At a press conference, Washington Governor Jay Inslee noted that the state's current incentive for e-Motorcycle purchase, a sales tax exemption, was "woefully inadequate". They hope that the proposed rebate would push a broader population segment to adopt electric vehicles. Finland also offers special compensation for those who switch from using cars to zero-emission transport options, like e-motorcycles and e-bikes (Kuva, 2021).

On the other hand, municipalities can effectively use bans and regulations to ensure reduced usage and emissions from motorcycles. Barcelona has implemented a low emissions zone, where only motorcycles made after 2,003 are eligible for permits to access the city centre during peak hours. The city has plans to strengthen requirements in the future (Wheelen, 2021). Paris has recently proposed a ban on all two-wheelers within the city to reduce noise emissions and emissions reductions (Interdiction des 2RM (scooters et motos) thermiques à Paris, n.d.).
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