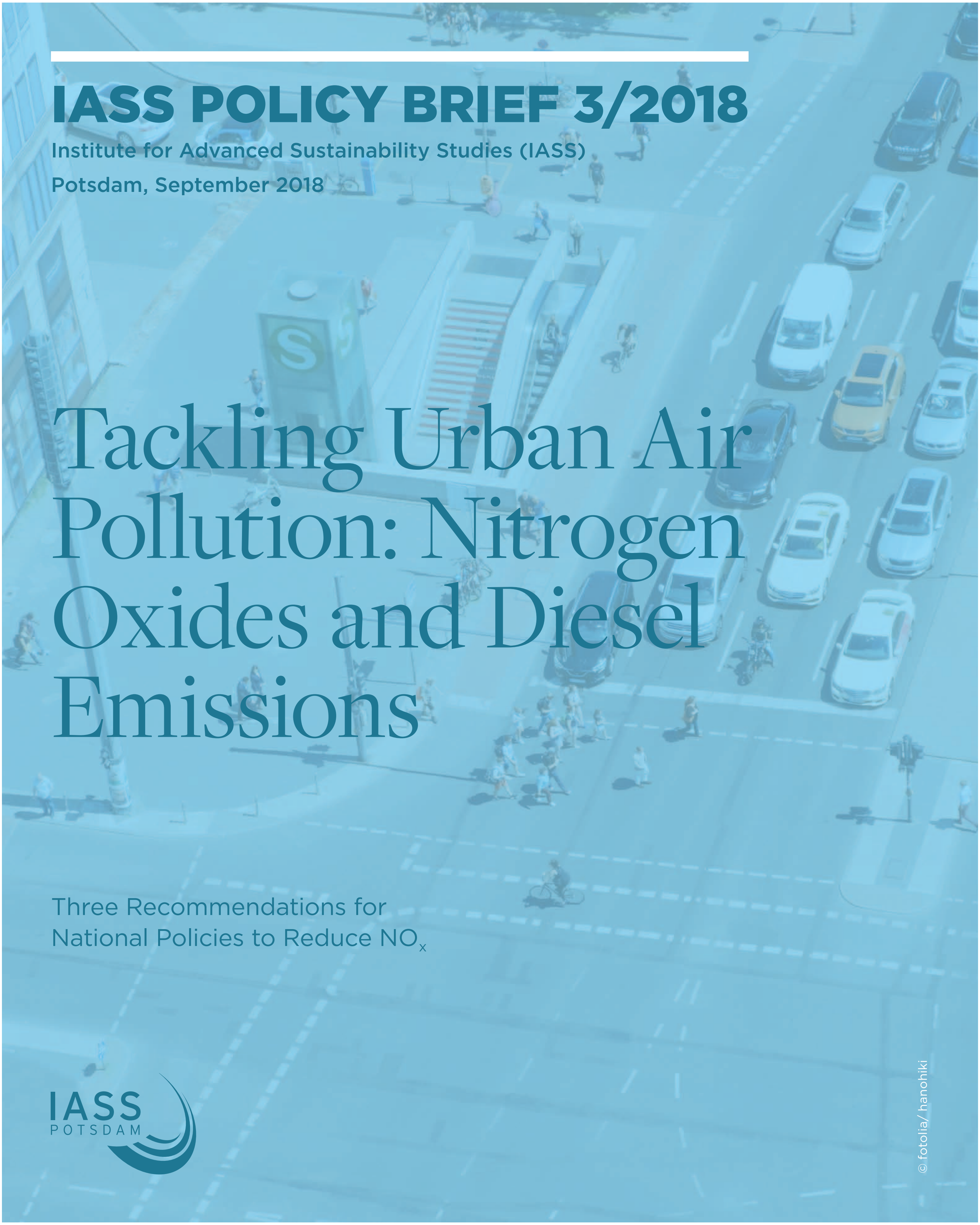

IASS POLICY BRIEF 3/2018

Institute for Advanced Sustainability Studies (IASS)

Potsdam, September 2018

Tackling Urban Air Pollution: Nitrogen Oxides and Diesel Emissions

Three Recommendations for National Policies to Reduce NO_x

IASS POTSDAM

This policy brief was written by Tim Butler, Erika von Schneidemesser, and Sophia Becker (IASS).

Ambient NO_2 concentration limit values are exceeded at more than half of all traffic monitoring sites in Germany. Since diesel passenger vehicles are the primary cause of these exceedances, measures that target these vehicles are the best way to bring German cities quickly into compliance. These measures should apply to entire urban areas, not just hotspots, and they should be based on real-world emissions.

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High Time to Take Action on Diesel Emissions

The cause of an estimated 4.2 million deaths globally in 2015,[1] ambient air pollution is the world's foremost environmental health issue. In many German and European cities, air pollution from nitrogen dioxide (NO_2)[2] has become a particularly pressing problem. More than half of all traffic monitoring stations in Germany registered exceedances of the yearly limit value of 40 micrograms (µg) per cubic metre for NO_2 in 2016. The most important source of NO_2 in urban areas is road traffic, particularly emissions from diesel vehicles. Short- and long-term exposure to nitrogen dioxide has been linked to adverse health effects, such as increases in all-cause mortality and respiratory and cardiovascular effects.[3] As time spent in traffic can have a disproportionately large effect on people's daily exposure to air pollution, it is vital that these exceedances are tackled together with the broader issue of mobility in order to protect human health and foster a sustainable urban future.

EU clean air legislation requires that the length of the period in which limit values are exceeded should be kept as short as possible. Recent action by the European Commission against Germany and several other countries shows that measures are urgently needed to reduce roadside NO_2 concentrations. And recent court rulings in Germany have indicated that in order for cities to fulfil this obligation, all possible measures that could contribute to meeting air quality standards can be considered – including banning diesel vehicles, since they are the primary cause of NO_2 concentration limit value exceedances.

■ Message 1

Extend measures to reduce NO_x emissions to entire urban areas

Limit values are consistently exceeded in locations with heavy traffic throughout urban areas, not just at "hotspots" in the vicinity of monitoring stations. To adequately protect human health, measures to reduce NO_x emissions from diesel passenger vehicles need to be implemented across whole urban areas.

■ Message 2

Design and enforce reduction measures based on real-world emissions

Given the discrepancy between the NO_x emissions car manufacturers register for their vehicles and those measured under real-world conditions, measures to reduce NO_x emissions from diesel cars must be based on real-world emission measurements. Proxies for estimating vehicle emissions, such as vehicle age, will not adequately address the issue.

■ Message 3

End subsidies for diesel fuel

The incentivisation of diesel vehicles through indirect fuel subsidies justified by their purported climate benefits should be phased out. Today's diesel passenger vehicles do not emit less CO_2 relative to their petrol counterparts. Furthermore, subsidies that support fossil fuel combustion work against long-term sustainability goals.

[1] Landrigan et al. 2017.

[2] In this Policy Brief we refer to both NO_2 and NO_x. NO_x denotes the sum of nitrogen dioxide and nitric oxide and is used in the context of emissions measurements. NO_2, on the other hand, is used in reference to pollutant concentrations and the limit values set for such concentrations in clean air legislation. See the more detailed description in the infobox on page 5.

[3] Faustini et al. 2014, Mills et al. 2015, Schneider et al. 2018.

Extend measures to reduce NO_x emissions to entire urban areas

In most German cities, and in many other European cities, exceedances of the annual average NO_2 concentration limit value (40 µg/m³) are reported for the limited number of monitoring sites located near major roads. This does not mean that NO_2 is only a problem at a small number of hotspots. Since monitoring sites are meant to be representative of the wider location,[4] we can assume that limit value exceedances at such sites are strongly indicative of widespread limit value exceedances near major roads in an entire urban area. The extensive nature of these exceedances at traffic locations has been confirmed by additional non-regulatory measurements performed by multiple groups in several cities.[5]

The composition of roadside NO_2

The concentrations of NO_2 measured at roadside sites are due to a combination of the emissions from vehicles in close proximity to the monitoring station, the so-called "urban background" concentration of NO_2 that exists throughout an urban area, and the regional background concentration (see figure 1). Urban background NO_2 concentrations reflect the full range of NO_x emission sources in the urban area, including road traffic, power generation, heating, and other industrial processes.

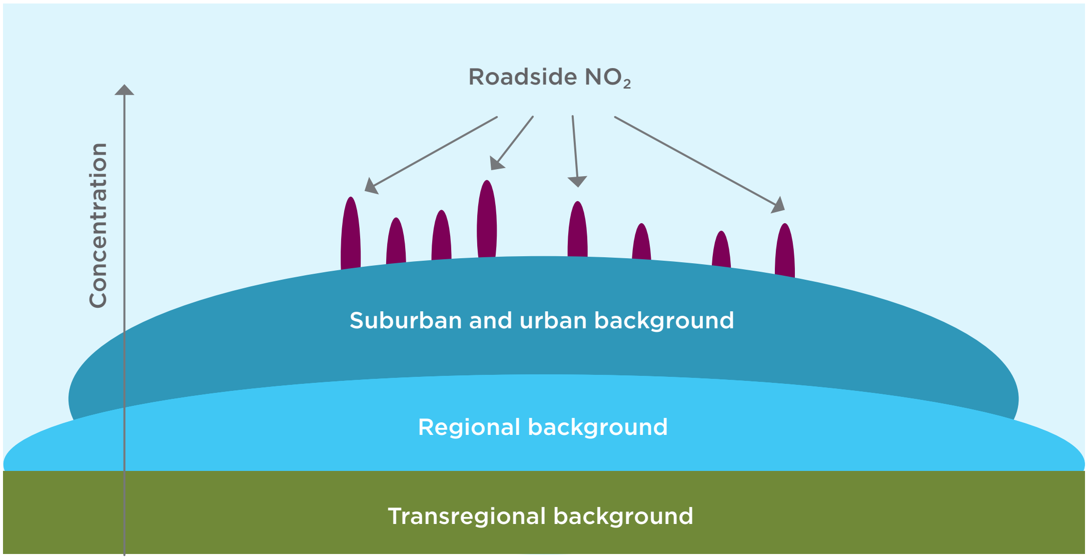

Figure 1: The relationship between background NO_2 and roadside NO_2

Source: Umweltbundesamt

[4] See the placement requirements for monitoring sites in Annex III of the EU ambient air quality directive (2008/50/EC).

[5] For example, the annual air quality reports released by the Berliner Senatsverwaltung für Umwelt, Verkehr, und Klimaschutz include a large set of measurements made using passive sampling techniques.

Road traffic is the single largest source of NO_x emissions in Germany, with diesel passenger vehicles accounting for most of this source. That means that diesel passenger vehicles contribute significantly to both roadside and urban background concentrations of NO_2. So a reduction in NO_x emissions from diesel passenger vehicles would be especially effective at lowering the roadside concentration of NO_2 given the simultaneous effect that would have on both urban background NO_2 and the roadside increment. Multiple studies have shown that the number of ambient NO_2 concentration limit value exceedances in cities can be substantially reduced if only vehicles that comply with the emission standards are allowed to enter.[6] If, on the other hand, only hotspots are targeted, there is very little evidence to suggest that drivers will not simply find alternative routes, which would just move the problem to other parts of the city. Moreover, public acceptance levels for measures that only tackle the symptom (e.g. by closing or restricting traffic on individual streets) and have negative side effects, such as shifting traffic to residential side streets, are generally low.[7] As long as the current fleet of diesel passenger vehicles continues to emit NO_x at levels far above the current emission limit values, any measures that target those vehicles should apply to entire urban areas.

Banning diesel cars from traffic hotspots could just shift the problem to residential areas.

NO_x and NO_2

Nitrogen oxides (NO_x) refer to the sum of nitrogen dioxide (NO_2) and nitric oxide (NO). The two gases are often referred to together because both are rapidly converted back and forth between NO_2 and NO after being emitted into the atmosphere (in what is known as the photostationary state). The balance between these reactions is one of the most important factors for determining ozone production, a major contributor to smog.

In Europe, the ambient air quality limit for the annual average of NO_2 is 40 $\mu g/m^3$. Vehicle emissions standards in Europe are based on NO_x emissions and have been implemented in stages for light-duty vehicles, more commonly referred to as Euro 1 through Euro 6.

[6] Degraeuwe et al. 2017, von Schneidemesser et al. 2017.

[7] Weiand et al. 2018.

Design and enforce reduction measures based on real-world emissions

The lack of progress towards meeting the EU ambient NO_2 concentration limit since it came into force in 2010 has been attributed to ongoing exceedances of NO_x emissions standards under real-world conditions by diesel passenger vehicles. For example, vehicles approved under the Euro 5 standard (which were sold between 2009 and 2015) emit on average about five times more NO_x than they are supposed to when tested under real-world conditions rather than in the laboratory (see figure 2 below).[8] That means that in terms of their NO_x emissions, Euro 5 vehicles are, on average, even more polluting than the predecessor Euro 3 and 4 vehicles. The stricter Euro 6 standard has been in force since 2014. Yet real-world testing of several early Euro 6 models (approved for sale before September 2017, see infobox on p. 7) reveals that while some comply fully with the standard under real-world conditions, others exceed it by a large margin.[9]

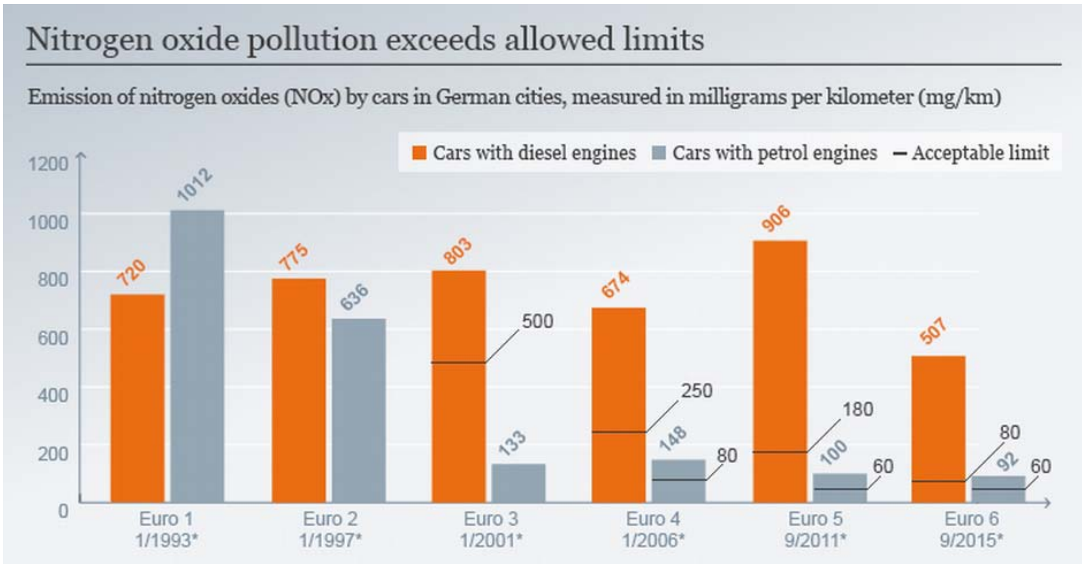

Figure 2: A comparison of NO_x emissions from petrol and diesel cars

Source: Umweltbundesamt

[8] Fontaras et al. 2014.

[9] O'Driscoll et al. 2016.

These exceptionally polluting Euro 6 diesel passenger vehicles can still be legally sold until September 2019 (see infobox). So until that date, consumers have no guarantee that new diesel passenger vehicles purchased in the EU will meet the Euro 6 standard for NO_x emissions. And based on vehicle fleet turnover, it will take years for these stringent new emissions standards to lead to significant reductions in the number of exceedances of ambient NO_2 concentration limit values.[10]

Strict adherence to Euro 6 in cities

In order to minimise the length of time in which ambient limit values are exceeded, it makes sense to allow only diesel vehicles that demonstrably meet the Euro 6 emission standard under real-world conditions into urban areas.[11] Restricting access based on vehicle age will not be effective, since this has been shown to be a poor indicator of real-world emissions. Non-compliant Euro 5 and 6 diesel vehicles can and should be retrofitted to bring them into line with the Euro 6 standard. To effectively enforce the selective entry of compliant vehicles into urban areas, it will be necessary to visibly differentiate them from non-compliant vehicles. Permits to enter urban areas should remain contingent on regular vehicle inspections based on real-world conditions.

Beyond the primary objective to improve air quality, clear regulation and law enforcement would also put an end to the current disorientation among consumers in the wake of successive diesel scandals. This disorientation would be replaced by growing public trust that diesel cars can live up to their manufacturers' claims as well as consumer expectations. And such reliability of expectations would ultimately benefit the car industry.

Gradual introduction of the Euro 6 standard for diesel passenger vehicles

The Euro 6 emission standard specifies a NO_x emission limit value of 80 mg/km for newly-registered diesel passenger vehicles. The standard came into force in September 2015. Real-world measurements of emissions from Euro 6 diesel vehicles have shown that they exceed the emission limit value by a factor of 6 on average (See figure 2). These vehicles can still be legally sold and registered in Europe until September 2019. After this date, all newly-registered diesel passenger vehicles must conform to the Euro 6 standard to within a gradually decreasing "conformity factor", which means that they may still exceed the emission limit value even after this date.

Euro standard (diesel passenger vehicle)	NO_x Emission limit (mg/km)	Approved under real-world conditions?	"Conformity factor" measured under real-world conditions	Maximum allowed "conformity factor"	Applies to new type approvals after	Applies to new registrations after
Euro 6	80	No	6	–	09.2014	09.2015
Euro 6d-temp	80	Yes	–	2.1	09.2017	09.2019
Euro 6d	80	Yes	–	1.5	01.2020	01.2021

Table 1: Implementing the Euro 6 standard – An Overview

Source: IASS

[10] Toenges-Schuller et al. 2016.

[11] Other types of compliant vehicles include those powered by petrol and natural gas, as well as hybrid and electric cars.

End subsidies for diesel fuel

The current set of incentives for the purchase and use of diesel vehicles is misguided: It works against air quality targets set to protect human health, contributes nothing to CO_2 reduction targets, and does not support long-term sustainability goals.

Where the current generation of diesel vehicles is concerned, the premise that diesel cars are good for the climate and will help Germany meet its emissions reduction target is false. The gap between the CO_2 emissions indicated by car manufacturers and those measured under real-world driving conditions is in fact larger for diesel cars than petrol cars.[12] Given consumers' preference for larger and more powerful diesel vehicles,[13] this means that modern diesel cars are just as CO_2-intensive per kilometre as their petrol counterparts. Indeed, EU targets for CO_2 emissions from road transport can still be met with just a 15 per cent diesel share in the entire car fleet.[14]

The psychology of fuel pricing

Recent research has shown that the significant air quality benefits that would result from reducing NO_x emissions from diesel vehicles would outweigh any few potential carbon disbenefits.[15] The lower fuel tax for diesel vehicles should therefore be phased out. Equalising the price at the pump for diesel and petrol would remove incentives to purchase diesel cars. The price of petrol serves as a mental anchor for consumers.[16] From this anchor point, diesel fuel is seen as comparatively cheap, and that makes it attractive for consumers to purchase diesel cars. The higher annual vehicle tax on diesel cars does not act as a strong deterrent, since psychologically, the monetary feedback of the fuel costs consumers pay around once a week correlates more directly with their consumption behaviour than a tax they pay only once a year.[17]

In addition to private consumers, professional fleet managers should also be discouraged from purchasing diesel cars. Currently, 89 per cent of all fleet cars in Germany are diesel cars.[18] Since 65 per cent of newly-registered cars are company cars, the decisions fleet managers make have a major impact on the composition of the German car fleet. By removing subsidies for diesel fuel, fleet managers would no longer be strongly motivated to purchase diesel cars.

The turn to fossil-free mobility

Finally, subsidies or incentives that support fossil fuel combustion hinder or delay efforts to achieve long-term sustainability goals. What is really needed is a mobility transition that fosters a shift from the use of individual, fossil fuel-powered vehicles, to more sustainable and/or renewable energy-powered transit options, such as public transport, cycling, car-sharing initiatives, and e-mobility. Such a transition would bring multiple benefits to a variety of areas, including human health, climate change, quality of life, and sustainable cities.

[12] ICCT 2016.

[13] Zachariadis 2013.

[14] ICCT 2017.

[15] Brand 2016; Holland et al. 2016.

[16] On the "anchoring effect", see Tversky & Kahnemann 1974, p. 1128.

[17] Wilhite & Ling 1995.

[18] https://www.dat.de/en-int/aktuell/news/statement-der-dat-zum-diesel-urteil-1106.html.

Targeted measures and a new approach to mobility

Ambient NO_2 concentration limit values are exceeded at more than half of all traffic monitoring sites in Germany, primarily due to the exceedance of NO_x emission limits by diesel passenger vehicles. In the absence of targeted measures, these limit values will continue to be exceeded for several years to come – in violation of European law and to the detriment of human health. Since diesel passenger vehicles are the primary cause of NO_2 limit value exceedances, measures that specifically target these vehicles are the best way to bring German cities quickly into compliance. Yet in order to have the desired effect, these measures should apply to entire urban areas, not just hotspots. And they should be implemented based on the real-world emissions of diesel vehicles, which are often significantly higher than the permitted limit values.

In addition to measures targeted at specific classes of vehicles, the incentives for consumers to choose diesel vehicles over less-polluting alternatives should also be abolished. This can be done without endangering climate protection goals. More generally, a broader range of urban mobility options, including improved public transport and cycling infrastructure, would also contribute to emission reductions while improving city-dwellers' quality of life. This requires a radical change in traffic infrastructure and city planning: less space for driving and parking and more space for cycling and bicycle parking as well as walking, sharing options, and public transport. There is a groundswell of support for such change: Representative surveys reveal that 79 per cent of Germans would like to have less cars in their city/community, with 91 per cent convinced that a reduction in the number of cars would contribute to better quality of life.[19] And, as shown by the overwhelming public approval for a plan to extend Berlin's cycling infrastructure, citizens are generally in favour of the measures that are necessary to make car-free modes of transport more attractive.[20]

The infrastructure for sustainable mobility options needs to be vastly extended in our cities.

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[19] Umweltbundesamt, 2017, p.65.

[20] For example, three quarters of Berliners (73%) support the city's plan to greatly extend cycling infrastructure: https://www.morgenpost.de/berlin/article208793731/Umfrage-Haelfte-der-Berliner-findet-rot-rot-gruenen-Senat-gut.html.

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Institute for Advanced Sustainability Studies (IASS) e. V.

Funded by the ministries of research of the Federal Republic of Germany and the State of Brandenburg, the Institute for Advanced Sustainability Studies (IASS) aims to identify and promote development pathways for a global transformation towards a sustainable society. The IASS employs a transdisciplinary approach that encourages dialogue to understand sustainability issues and generate potential solutions in cooperation with partners from academia, civil society, policymaking, and the business sector. A strong network of national and international partners supports the work of the institute. Its central research topics include the energy transition, emerging technologies, climate change, air quality, systemic risks, governance and participation, and cultures of transformation.

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