MISSION ~~IM~~POSSIBLE:

How car makers can reach their 2021 CO_2 targets and avoid fines

TRANSPORT & ENVIRONMENT

Transport & Environment

Published: September 2019

© 2019 European Federation for Transport and Environment AISBL

Editeur responsible: William Todts, Executive Director

Further information

Florent Grelier
Clean Vehicles Engineer
Transport & Environment

florent.grelier@transportenvironment.org
Mobile: +32 488 92 84 11

Square de Meeûs, 18 – 2nd floor | 1050 Brussels, Belgium
www.transportenvironment.org | @transenv | fb: Transport & Environment

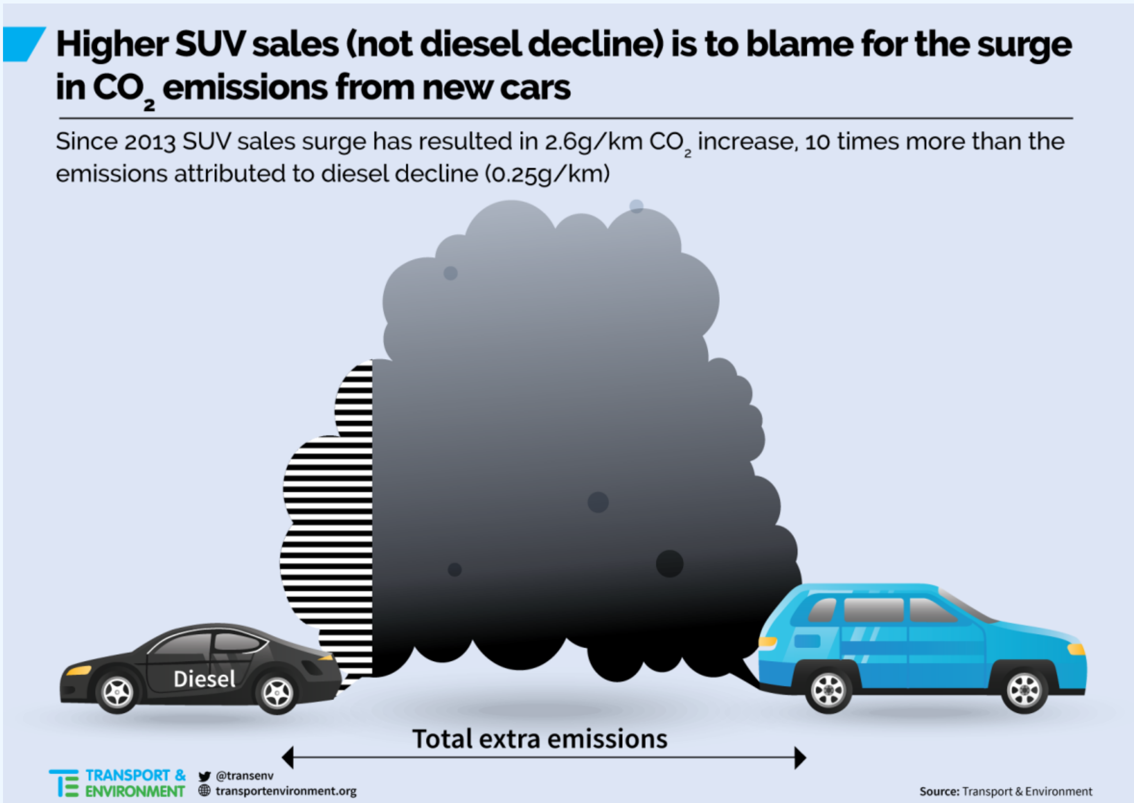
Acknowledgements

This report was prepared by Transport & Environment based largely on data compiled by the European Environment Agency. Analysis was undertaken by Florent Grelier with the support of Thomas Earl. The report was written by Greg Archer and reviewed by Julia Poliscanova. The Editor-in-Chief is William Todts.

Executive summary

Reducing CO_2 emissions from all new cars and accelerating the uptake of zero emission models is essential to prevent a climate emergency. This is not a silver bullet - local and national policies need to reduce car ownership and use and promote active travel and shared mobility, which are also important. The EU car CO_2 law setting a 95 g/km target for 2020/21 agreed a decade ago was intended to achieve a step change in car emissions crucial to decarbonising transport. But just 16 months before the target comes into force carmakers are less than halfway towards their goals. This report examines why progress has been so slow and shows targets should still be met if companies invest to deliver the planned production goals for electric vehicles (both zero emission and plug-in hybrid models) and to make conventional cars more efficient. Some companies may also need to incentivise customers to opt for lower CO_2 variants, such as by selecting a model with a slightly less powerful engine. The cost of the investments required to meet the CO_2 standard is estimated to be about half of that incurred by the penalties that would kick in if carmakers fail to comply.

The pitiful progress to date has been caused primarily by three factors. Firstly, a failure to significantly improve the CO_2 emissions from conventional engined cars by fitting more clean technologies. Secondly, the very limited supply of zero emission and plug-in hybrid models, purposefully constrained by carmakers to keep selling conventional models. Thirdly, a huge growth in sales of SUVs that have leapt from 7% in 2009 to 36% in 2018 and are expected to reach nearly 40% by 2021. On average, SUVs have CO_2 emissions 16 g/km (or 14%) higher than an equivalent hatchback model, and for every 1% shift in the market to more SUVs, the CO_2 emissions increase by 0.15 gCO_2/km on average. In other words, the increase in SUVs since 2013 has had a CO_2 effect 10 times more than the diesel decline. In reality, carmakers' performance is even more disappointing since half of the emissions reductions since 2008 happened through manipulation of the official laboratory tests.



Toyota is best placed to be able to reach its target and has uniquely lowered emissions through increasing deployment of full hybrid technology. The Renault-Nissan-Mitsubishi Alliance has the next smallest gap to close in large part due to an early focus on sales of EVs. The companies with the largest gap are: Honda, Hyundai-Kia, Daimler and Volvo, but the latter two are expected to comply shifting a large part of their sales to plug-in-hybrid technology. Fiat-Chrysler also have a large gap but following their pooling with Tesla is comfortably placed to achieve its target. It is clear most carmakers have chosen to pursue short-term profit focused strategy, delaying the necessary investments until the last possible moment.

Compliance plans to meet targets will comprise of four principal elements:

1. increasing sales of zero emission and plug-in hybrid electric vehicles (the most future-proof strategy);
2. investing in technology to lower CO_2 emissions of conventional vehicles (including mild and full hybrids);
3. pricing, sales and marketing approaches to encourage customers to buy smaller and less powerful engines (with margin implications); and
4. pooling with another company (like FCA with Tesla).

The report assesses which combination of measures carmakers will need to adopt in order to meet their targets and is summarised in the figure below.

Overall, the analysis forecasts the **EU-wide sales of EVs** will go from 2% in 2018 (2.9% in June 2019) to **5% in 2020** (3-7% range) and **10% in 2021** (7-12% range). Around half of sales are expected to be ZEVs and half PHEVs. The jump in EV sales in 2021 results from the EU CO_2 target applying to all cars sold in 2021 (not 95%) and because many carmakers will need to make use of most of their super-credit allowance in 2020 already to meet the target. The range results from the flexible design of the regulation that allows carmakers to do more or less to lower the CO_2 emissions of conventional cars (e.g. by shifting sales to lower CO_2 variants or limiting sales of highest emitters, such as sports cars and premium SUVs).

The rise in EV sales is significant but new data from IHS Markit anticipates a tripling in the number of EV models available by 2021 and a corresponding large increase in production. To meet targets carmakers will need to ensure the planned production is available on time, or will need to resort to last-resort approaches like ending sales of their highest emitting models that deliver high margins. However, there are good reasons for optimism that the new production in coming years will be sold. Surveys of prospective buyers indicate an immediate untapped market of at least 10%. EV prices will fall with cheaper batteries and large-scale production facilities. Most governments have implemented tax breaks and grants reducing the higher upfront costs for private buyers, and the total costs of owning an electric car are falling sharply, making this an attractive option for fleets. New charging infrastructure is being installed EU-wide and more charge points are rolled out across main EU motorways and in residential areas. In addition, sales in Norway now count towards the target where 50% of new car sales are now EVs. A large increase in sales and marketing efforts is also changing buyer attitudes with EV advertisement now commonplace in many markets and an array of EV launches planned for this year's Frankfurt Motor Show. Some companies will offer whole small city car range as electric, or seek to stock their car sharing fleets with electric cars; others will encourage staff to take EVs as company cars as a means to ensure the necessary sales are achieved. Achieving the required EV sales is a realistic prospect despite the current wide gap to be bridged.

How many electric cars carmakers need to sell in 2021 to avoid fines

% of total vehicle sales

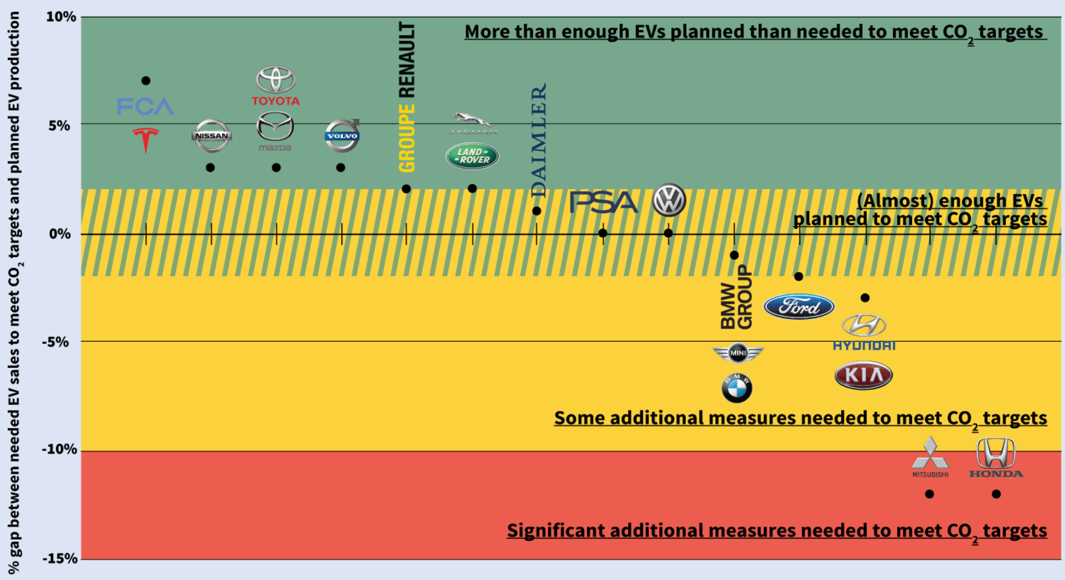
Carmaker	EV shares needed to meet 2021 EU CO_2 targets		
	Scenario 1 More combustion engine improvement	**Scenario 2** 1 + lower CO_2 variants	**Scenario 3** 1 + 2 + stop sales of highest emitters
TOYOTA, mazda	**Business as usual scenario is enough with 1%**		
PSA	8%	3%	2%
GROUPE RENAULT	10%	5%	3%
Ford	13%	5%	3%
FCA, Tesla	13%	8%	5%
VW	13%	8%	5%
HYUNDAI, KIA	13%	7%	5%
EU average	12%	7%	5%
HONDA	16%	12%	11%
NISSAN	16%	9%	6%
BMW GROUP, MINI	16%	11%	8%
DAIMLER	18%	12%	10%
JAGUAR, LAND ROVER	19%	13%	10%
MITSUBISHI	24%	18%	16%
VOLVO	23%	19%	16%

TRANSPORT & ENVIRONMENT
@transenv
transportenvironment.org

Source:Transport & Environment

Gap between EV sales needed and production planned for 2020

Most carmakers on track to produce enough EVs to meet the CO_2 targets

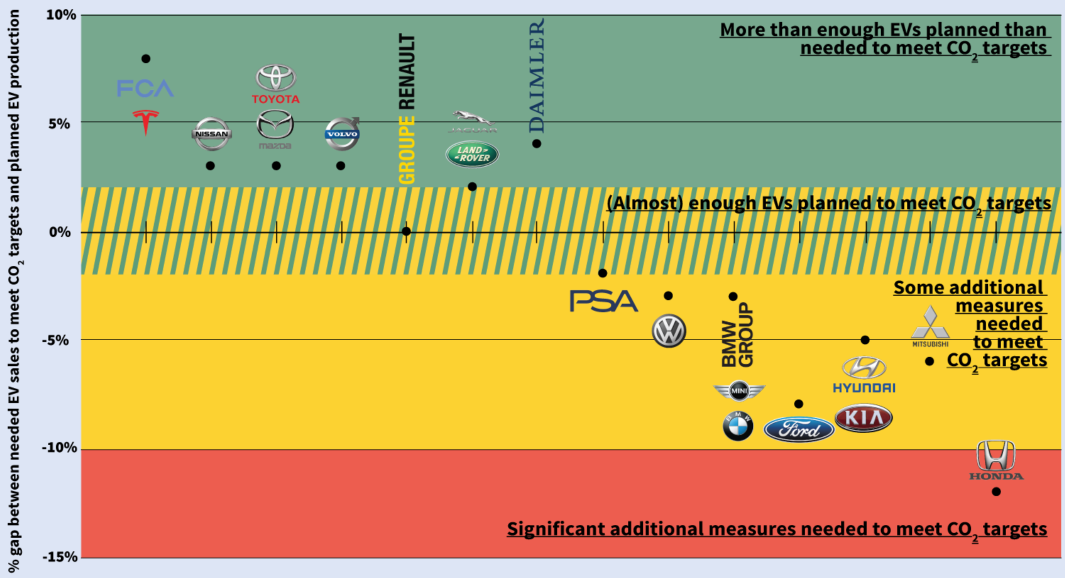


TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Transport & Environment

Gap between EV sales needed and production planned for 2021

Most carmakers on track to produce enough EVs to meet the CO_2 targets



TRANSPORT & ENVIRONMENT @transenv transportenvironment.org

Source: Transport & Environment

To ensure the regulation achieves its objective and is met there are several actions policy makers should take. Firstly, the car CO_2 law is the centrepiece of EU transport emissions policy, it was agreed a decade ago and most carmakers have invested billions in order to comply. The new European Commission should enforce the regulation as intended and not introduce any last-minute weakening under pressure from carmakers or their governments. Secondly, the Commission and Member State testing services and type-approval authorities must ensure there is no manipulation of test results through an extensive process of conformity checking. Thirdly, governments should assist in the shift to zero and low emissions vehicles by reforming systems of car taxation to increase incentives for zero emission vehicles and raising taxes on high CO_2 models. Making high mileage fleets such as taxis and corporate fleets zero emission as soon as possible (as some countries are already doing) will also accelerate EV uptake, as will support for installing charging infrastructure.

The analysis presented in this report shows that although carmakers have fallen far behind the targets, they can and should be met. The 12-year lead time before the target fully applies has unquestionably been wasted by most carmakers except Toyota and Renault-Nissan. Claims that the fall in diesel sales is the cause of rising emissions are false - it is the rise in SUVs, driven by carmakers aggressive marketing of these vehicles that have been the main driver of rising emissions. If the companies do incur penalties they will only have their own bad decisions and woeful planning to blame, and the penalties will be a necessary reminder they have environmental responsibilities that cannot be ignored.

Table of Contents

List of acronyms

% pa	Percentage per annum
BaU	Business as Usual
CO_2	Carbon dioxide
CO_{2eq}	Carbon dioxide equivalent
EEA	European Environment Agency
EU	European Union
EU13	Member States who have joined the European Union since 2004
EU15	Member States who have joined the European Union before 2004
EU28	European Union including 28 Member States, i.e. with the United Kingdom
EV	Electric vehicle, including plug-in hybrid and zero emission vehicles
GHG	Greenhouse gas
HEV	Full Hybrid Electric Vehicle, to be considered as an ICE car
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine, i.e. conventional powertrains (diesel or petrol mainly)
JRC	European Commission's Joint Research Centre
LED	Light-Emitting Diode
LPG	Liquified Petroleum Gas
NEDC	New European Driving Cycle, EU's former laboratory test procedure
NOx	Nitrogen oxides
OEM	Original Equipment Manufacturer
pkm	Passenger kilometre
PHEV	Plug-In Hybrid Electric Vehicle
SUV	Sport Utility Vehicle
T&E	Transport & Environment
TCO	Total Cost of Ownership
UK	The United Kingdom
WLTP	Worldwide harmonized Light vehicles Test Procedure, EU's current laboratory test procedure
ZEV	Zero Emission Vehicle

1. CO_2 emissions from cars

1.1 Drivers of increasing emissions

The world is currently on track for three degrees of global warming by 2100, double the aspiration of the Paris Climate Agreement. It is a nightmare scenario in which the reckless overuse of fossil fuels imposes enormous economic and human costs. Transport is Europe's biggest source of carbon emissions, contributing nearly 30% to the EU's total CO_2 emissions. Cars emit 44% of transport emissions (Figure 1) which since 1990 have risen and are still rising. To achieve the Paris goals and avoid a climate emergency, road transport CO_2 emissions will need to be entirely decarbonised by 2050 which will require the sale of the last car with an engine ideally by 2030 and by 2035 at the latest.

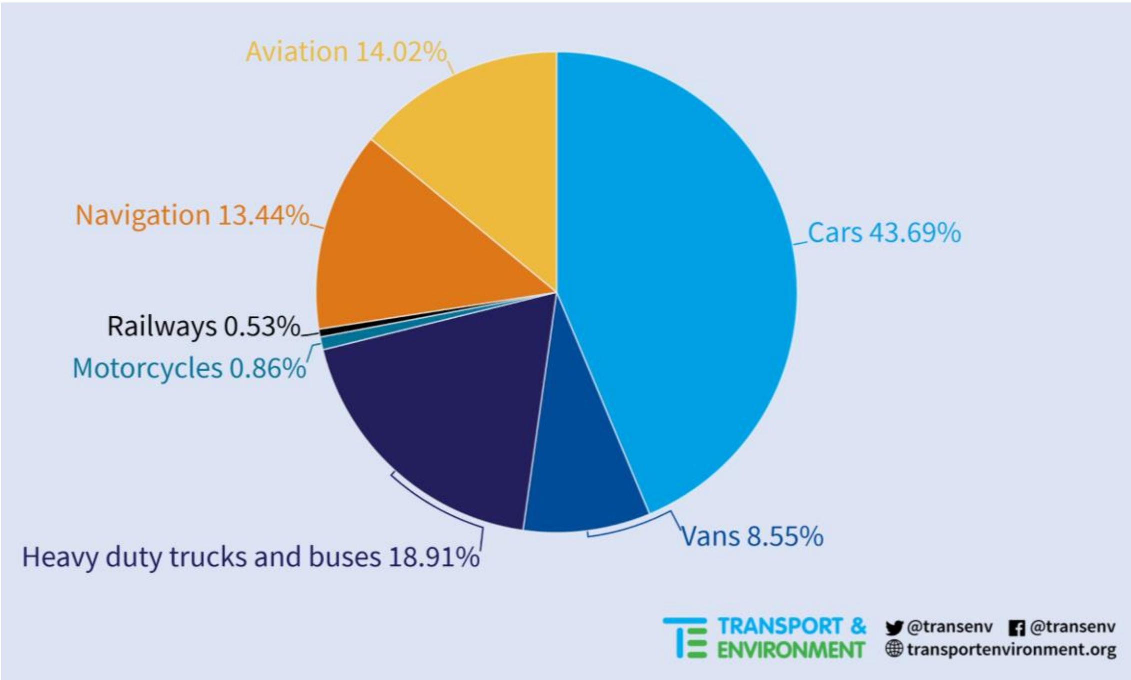


Figure 1 - EU transport greenhouse gas (GHG) emissions per sector in 2017

EU CO_2 emissions from cars have risen since 1990 from 461 to 543 million tonnes CO_{2eq} in 2017. They declined during and immediately following the financial crisis but are now increasing again. If the lifecycle emissions of biofuels were properly accounted for (instead of being considered fully renewable), greenhouse gas emissions from cars and vans would be on average 10% higher than official figures. The increase in car CO_2 emissions is being driven by a combination of factors:

1. Total travel continues to increase so car passenger kms (pkm) is rising at about 1% per year (Figure 2) and cars continue to be used for about 71% of all pkms. The growth in car use is largely driven by an increase in EU13 countries[1] where car ownership is growing and the share of public transport falling. This unsustainable trend is forecast to continue: between 2000 and 2025, car ownership rates in EU13 countries are expected to double whilst those in EU15 are projected to rise by a quarter.
2. Efficiency improvements on the road have been extremely modest (about 1% pa) despite the introduction of new car CO_2 emission. In 1995, CO_2 emissions on the road from new cars were around 203 g/km.[2] Today, they are still around 170 g/km.

[1] Newer EU members - largely from Central and Eastern Europe

[2] Based upon NEDC emissions of 186g/km in 1995 and a 9% gap between test and real-world emissions (this gap corresponds to the year 2001 from ICCT data and is assumed to be the same for 1995)

3. Sales of lower carbon alternatively fuelled vehicles have failed to grow significantly - constrained by a lack of market choice and high prices. However, sales are now growing quickly. In the first quarter of 2019, 8.5% of new car sales were alternatively fuelled: 4.6% hybrids; 2.5% electric vehicles (EVs including zero emission and plug-in hybrid models). EV car sales grew by 40% year on year and hybrids by a third.

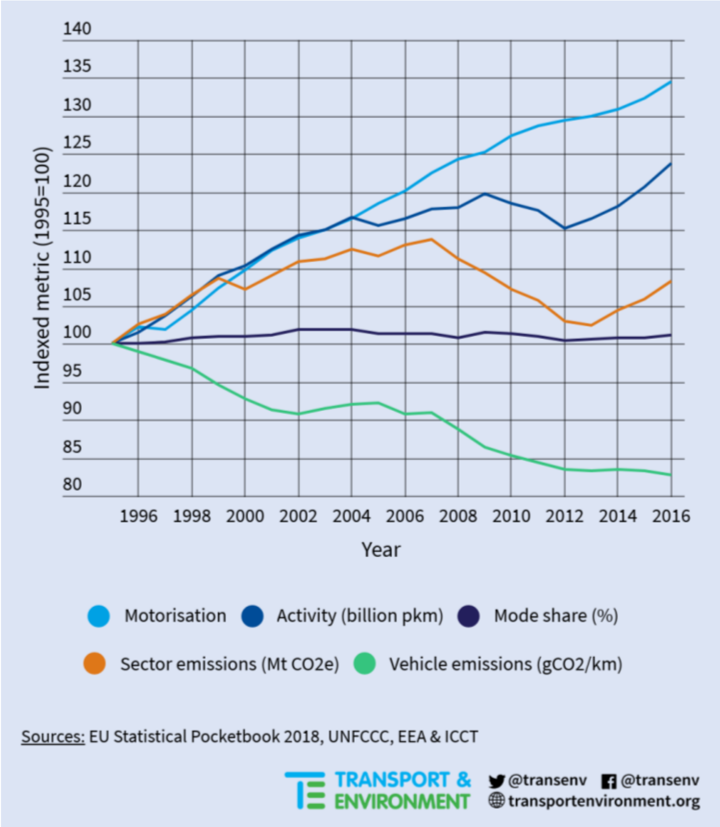


Figure 2 - Drivers of rising car CO_2 emissions

This report focuses on one of the tools to reduce CO_2 emissions from cars - lowering the CO_2 emissions of new cars and driving the shift to zero (tailpipe) emissions through CO_2 regulation of new cars. This is one of the EU's biggest carbon saving regulations, but tackling car CO_2 emissions cannot rely exclusively on one approach. Policies to encourage sharing of vehicles and trips rather than private ownership of cars is also essential to encourage better travel choices when and where private cars are used, to lower the pkms being driven. Improved alternatives to the car, including public transport, walking and cycling infrastructure must be installed to encourage drivers out of their cars and provide real choice. Tax policies must reward shifts to less car use including through road pricing. However, it is clear the car will remain an intrinsic part of personal mobility for at least the first half of the twenty-first century and lowering the emissions of new cars is a key element of lowering emissions.

1.2 This report

The introduction to this report has documented the dominant role of car CO_2 emissions on overall transport emissions and the importance of shifting to lower and zero emissions (tailpipe) models as one strategy to lower overall car emissions but which must be complemented by policies to reduce car use overall.

Section 2 examines the long-term trends in new car emissions and also how new car emissions vary across the EU as a result of national car tax policies. It also describes the history of new car CO_2 regulation and shows how it is long term trends that are driving the recent trends to rising emissions.

Section 3 examines in detail how the shift to bigger and more powerful cars have offset much of the progress to reduce emissions to date and are now the primary cause of rising emissions. It also considers the effect on emissions of the decline in diesel car sales and failure to supply sufficient alternatively fuelled vehicles and technology to lower emissions.

Section 4 focuses on the different compliance strategies companies are using to achieve 2020/21 targets, and examines in detail which companies are comfortable to achieve targets, and those at risk of penalties and how these can still be avoided.

Section 5 presents conclusions and some future policy recommendations regarding the shape of future regulations and national taxes to help carmakers achieve future goals.

2. New car CO_2 emissions trends

2.1 Long-term trend

The history of new car CO_2 regulation to date is one of deception and failure. Deception since progress on the road is half of that in laboratory tests. Failure that initial targets were missed or too easy to deliver whilst in recent years progress has stalled and gone into reverse. There are, however, promising indications current and future rules will finally lower emissions and accelerate the transformation to lower and ultimately zero emission (tailpipe) cars. Figure 3 shows the long-term trend in new car CO_2 emissions both measured in the official laboratory test used in the past (NEDC) and real world emissions based upon a range of fuel consumption statistics. The following sections examine what has driven this pattern of emissions reductions to take lessons for how to accelerate progress in the future.

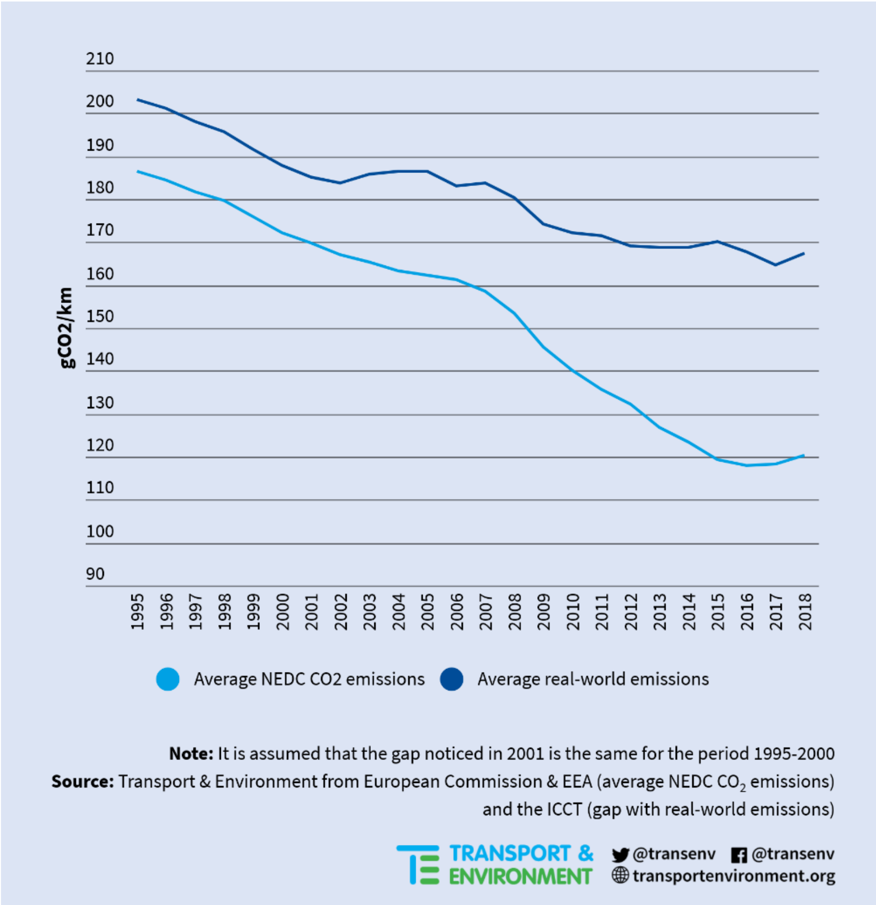


Figure 3 - New car average CO_2 emissions measured using the NEDC test and calculated in the real world

2.2 National progress

The EU wide trends are not necessarily reflected at a national level where tax policies significantly influence which cars are bought as shown in Figure 4. The highest average new car CO_2 emissions are in Estonia and Luxembourg which still average over 140 gCO_2/km. The lowest is in Portugal and the Netherlands (106 gCO_2/km). Since 2014, the biggest reduction has been achieved in Finland and Latvia (11 gCO_2/km); the smallest in the UK where emissions have risen by 0.1 gCO_2/km. The Netherlands used to have one of the highest new car CO_2 emissions in the EU but radically improved vehicle taxation to bring down emissions sharply. National tax policies have a significant influence on the cars sold and Governments could do much more to incentivise buyers to choose more efficient and electric models. Further information on national statistics is detailed in Annex 2 - Trends per Member State (2013-2018).

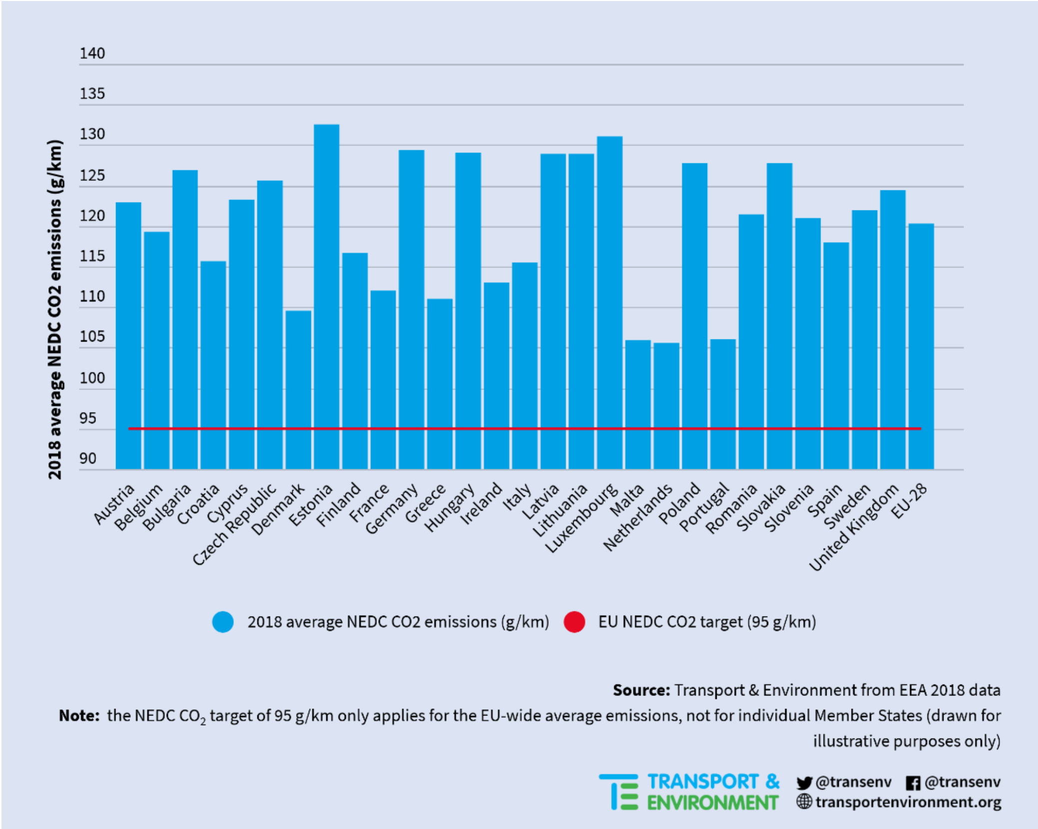


Figure 4 - National new car CO_2 emissions in 2018

2.3 Early attempt at reducing emissions - Voluntary agreement

The first new car CO_2 controls were introduced in 1998, as a Voluntary Agreement between the European Commission and the car industry and were intended to reduce emissions from new cars by 25%. However, the agreement failed, achieving only 18% of improvement instead. Figure 3 illustrates that from 1995 to 2001 the Agreement was initially effective reducing emissions both in the lab and on the road at an average of 1.5% pa. This was in part due to a sharp increase in the share of diesel cars which jumped from around 1 in 5 to 1 in 3 new cars sold. The growth in diesel sales had begun around 1990 and was initially boosted by the introduction of engines with improved direct injection with common rail systems and improved turbochargers. Lower rates of tax on diesel fuel and more lax emissions standards on diesel cars helped keep costs down and promote sales.

Figure 3 also shows that from 2002 to 2007, towards the end of the Voluntary Agreement, there was no progress in reducing emissions on the road as the gap between test and real world emissions began to grow (from 10% to 17%). The rate of progress in the laboratory also slowed to 1.1% pa. Figure 5 illustrates the primary causes for the slowdown in progress, carmakers increasing the engine power (by 10%), size and weight of cars (that grew by nearly 100 kg over the period). SUV sales, that had been niche at around 3% of the market, also started to grow - doubling over the period. The small decline in lab-measured emissions was in large part achieved by a surge in diesel sales to over 1 in 2 new cars, which helped to offset the loss in efficiency from other changes. These early market trends are now creating challenges for carmakers to meet better designed and more ambitious regulations.

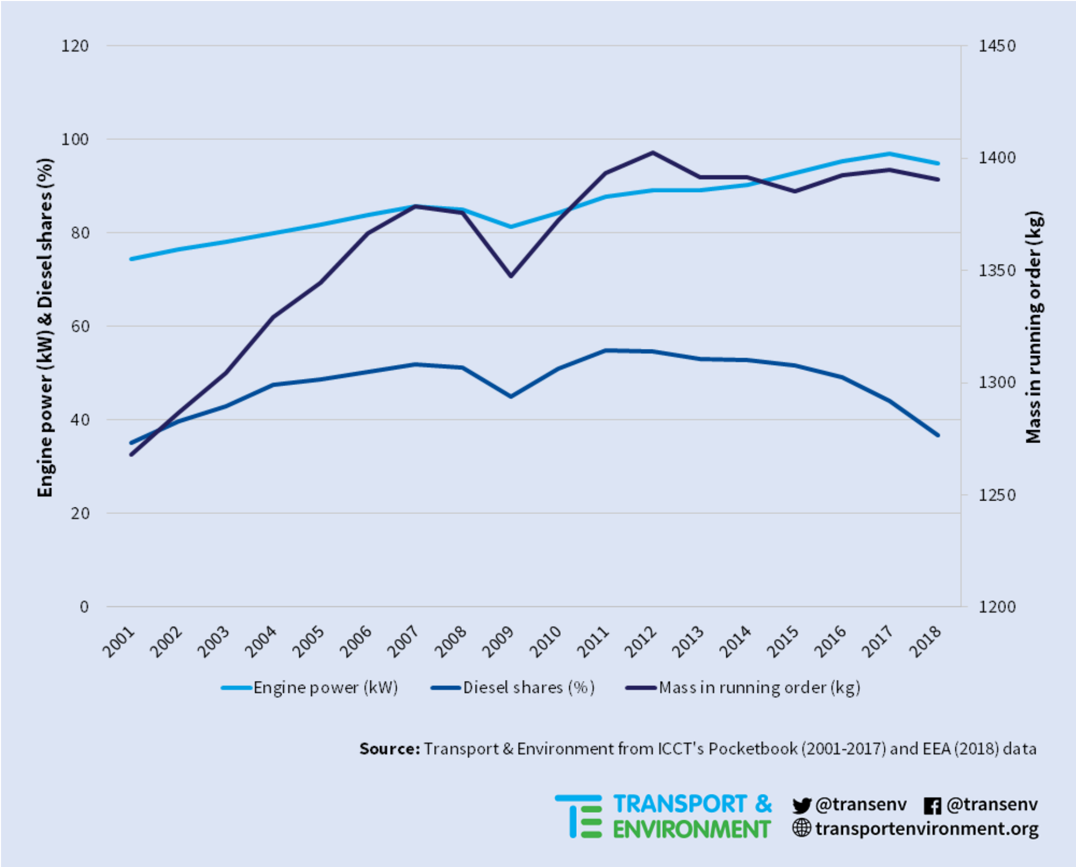


Figure 5 - Trends in key car characteristics affecting CO_2 emissions

2.4 Targets for 2015

The first regulation of car CO_2 emissions was adopted in 2009 setting targets of 130 gCO_2/km (based upon the NEDC laboratory test) that was phased in between 2012 and 2015. All major carmakers comfortably achieved the soft 130 gCO_2/km target, many several years early. Progress was greatly aided by the financial crisis which precipitated a strong decline in CO_2 emissions as the average size of cars bought reduced along with their weight and SUV sales also fell. The diesel share initially dropped then rose again peaking at 55% in 2011.

Attainment of the 2015 target was greatly assisted by carmakers continuing to find new ways to manipulate NEDC test results to achieve ever lower emissions in the lab. Between 2008 and 2011 emissions in tests fell at 3.8% pa but progress on the road was half of this level. As a result, the average gap between test results and real-world emissions more than doubled from 20% in 2009 to 42% in 2016. From 2012 to 2016, virtually all the improvement in CO_2 was achieved in the laboratory where emissions fell at 2.7% pa with an on-road reduction of just 0.4% pa. Had the gap between test and real-world performance been retained at 20% the official NEDC test values would be around 22 gCO_2/km higher and the 2015 target would have been missed. In reality, meeting the weak 2015 target was largely an illusion.

A range of factors contributed to the gap widening alongside carmakers abusing test flexibilities. Notably the widespread adoption of stop-start technology that was fitted to a quarter of new cars in 2011 and three quarters by 2016 made a large difference to emissions on the NEDC test in which the car is stationary for a fifth of the time - much more than the average drive. Downsized more efficient direct injection petrol engines also began to enter the market increasing to around 50% of petrol powertrains by 2017. These engines achieved impressive reductions in emissions driven on the undynamic NEDC test but not by more aggressive drivers on the road. Both are illustrative of technology deployment being primarily driven by the need to reduce emissions in tests not in reality.

2.5 Current regulations for 2020/21

The original 2009 regulation also adopted a more effective target of 95 gCO_2/km for 2020 but a fiercely fought review of the rules finalised in 2014 phased in the target so that just 95% of sold cars count towards the 2020 target with all cars being included in 2021. The 2020/21 regulation, which effectively applies from the beginning of 2020, is complex with numerous flexibilities intended to maintain fair competition between carmakers and allow different compliance approaches. For example, each carmaker:

1. Has their own target based upon the average weight of cars sold (the target for Fiat-Chrysler is currently 92g CO_2/km, and that for the BMW Group is currently 102 gCO_2/km).
2. Can pool (combine sales and emissions with other companies) to enable an averaging out of emissions across manufacturer groups and to encourage manufacturers of only electric cars (such as Tesla).
3. Can also claim off-cycle credits (eco-innovations) for fitting technology to the car that delivers emissions reductions on the road but not during the test (such as LED headlamps that are not switched on during the test).
4. Producing a small volume of vehicles is treated differently. A weight-based target only applies to pools selling more than 300 thousand models in Europe in a given year. Jaguar-Land Rover therefore can apply for a derogation for an easier target (about 130 gCO_2/km) than it would under the weight-based system (115 gCO_2/km). Carmakers selling very small volumes effectively set their own targets.
5. Can claim up to 7.5 gCO_2/km of super-credits, additional credits for sales of cars with emissions below 50 gCO_2/km which can be used between 2020 and 2022 (super-credits were introduced as part of the agreement on the 2014 review).

Carmakers are now working towards the 2020/21 goals; but since 2016, the official new car CO_2 emissions have been rising, a trend reinforced in the most recent provisional data for 2018 from the European Environment Agency (EEA) which shows current fleet average new car CO_2 emissions (based upon the NEDC test) are 120.4 gCO_2/km significantly above the 95 gCO_2/km 2020/21 targets and 2.3 gCO_2/km higher than the minimum level achieved in 2016.

The current increase in new car emissions is frequently portrayed by carmakers as the result of the unexpected sudden market shift away from diesel caused by Dieselgate. The evidence indicates it is rather the result of the long-term trends to bigger and more powerful cars. The diesel market share has declined since 2012 and that of SUVs rocketed up to a quarter of sales in 2016 and over a third in 2018. Engine power has increased sharply between 2012 and 2017 by another 10%; although weight was stable at around 1400 kg reflecting an increasing focus on light-weighting. To date, sales of alternatively fuelled vehicles have also been modest. These long-term trends are now creating considerable challenges for carmakers to meet their 2020/21 targets and are necessitating sudden shift in sales to lower and zero emissions vehicles as a result. Those companies that have planned well are now on a secure glide path to achieving the targets whilst those whose preparation was piecemeal are now struggling to achieve their goals.

A further contributing factor to the rise in new car emissions is that the industry has been unable to exploit even more flexibilities in the NEDC test to continue to lower emissions in the lab. Both T&E and the ICCT produced a series of critical reports drawing attention to the practices to deflate test results and the Dieselgate scandal exposed the way carmakers cheated and exploited loopholes in regulations. The European Commission has now closed some of the most egregious loopholes in the NEDC test and with the switchover to the WLTP test, the gap between NEDC test and real-world emissions in 2017 actually shrunk to 39%. Manipulating test results has been a key compliance strategy but most of the opportunities have now been exploited.

2.6 Future regulations

At the end of 2018, new EU targets were agreed for 2025 and 2030 to lower new car CO_2 emissions by 15% and 37.5% respectively from 2021 levels. The basis for the regulation are measurements made using the new WLTP test and the absolute values will be based on 2021 sales. Achieving the 2025 and 2030 targets will require carmakers to further develop their compliance strategies. Specifically, it will become increasingly expensive to meet these goals through improving the efficiency of cars with engines and a progressive shift to EVs will be needed. The targets do not include a specific mandate for EVs but do reward carmakers that exceed a benchmark level for these vehicles and for cars sold largely in EU13 countries where the market is less developed. The report considers the degree to which current compliance strategies will be appropriate in the next 10 years and beyond.

Beyond 2030 complete decarbonisation of the car fleet will be necessary to achieve net zero emissions by 2050. There is increasing consensus from policy makers, carmakers and environmentalist the solution principally lies in a fleet of battery electric cars. Hydrogen fuel cells are also expected to make a niche contribution but it is highly unlikely electrofuels could be produced in the volumes needed to power the car fleet and will anyway be needed to decarbonise aviation. Hybrids and plug-in hybrids will not provide a long-term solution as zero emissions (in use) will be essential. A fleet of zero emission vehicles by 2050 requires selling the last car with an engine ideally by 2030 and by 2035 at the latest. Several Governments are now moving in this direction as attention is turned to how to achieve net zero emissions. At present, EU single market regulations preclude banning all cars with engines. But EU Member States could choose to implement aggressive tax policies that effectively achieve the same outcome.

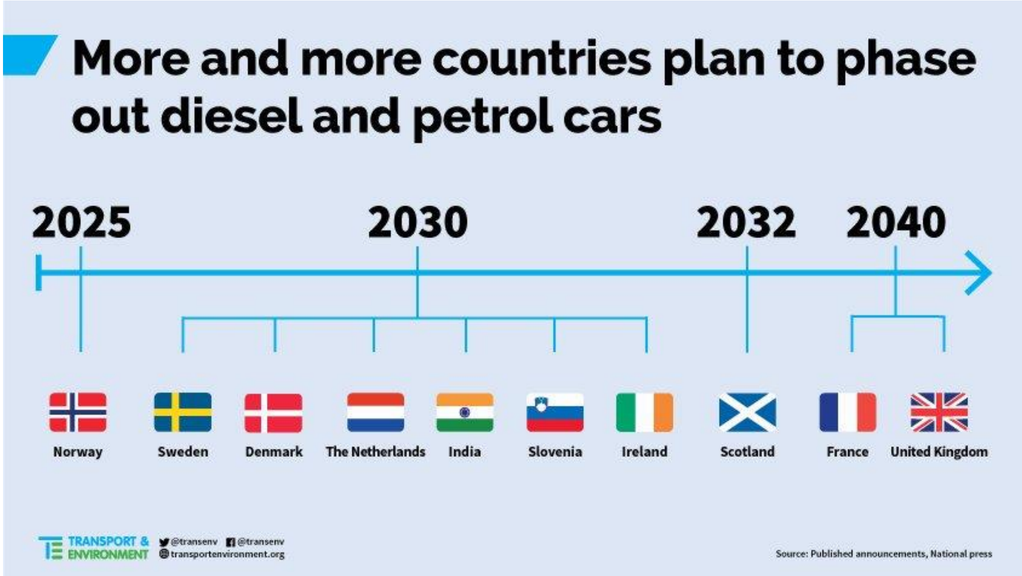


Figure 6 - Proposed dates to end the sale of ICE cars

Companies struggling to meet 2020/21 targets that fail to rapidly reduce CO_2 emissions from the cars they sell will become increasingly unprofitable and uncompetitive. The report therefore provides important insights into the readiness of carmakers to respond to the opportunities and challenges the transition to a net zero world creates.

3. Why has progress stalled?

The historical trends outlined in Section 2 highlight the important factors that lie behind the recent rise in official new car CO_2 data:

1. Real CO_2 emissions on the road have not significantly improved since 2012 and the biggest improvement in the official data originates from the widening gap between lab test and real-world performance. This has contributed half of the 35% reduction in emissions since 1995. Since the gap stabilised in 2015, and recently began to close slightly, the trend in official new car emissions has been upwards.
2. The decline in diesel sales dates from 2012 but has significantly accelerated since the Dieselgate scandal.
3. A large increase in the power of cars has offset measures to reduce emissions together with an increase in the size, and until 2014 the weight of cars has offset measures to reduce emissions.
4. There has been minimal deployment of advanced technology to significantly lower emissions. The share of hybrid electric cars has only grown slowly reaching about 3% in 2018. Only Toyota and Lexus with nearly 60% of vehicles being hybridised have made significant use of this technology despite the huge increase in larger SUV vehicles.
5. The share of EVs has also remained low - although is now growing quickly. EVs represented 2% of sales in 2018, and all alternatively powered vehicles only 7.3%.

Overall, it is no surprise emissions are now rising. The following sections look in detail at the contribution of the key drivers.

3.1 The impact of declining diesel sales

Dieselisation has been an important long-term compliance strategy for carmakers to lower CO_2 emissions in the past and declining sales have had a small contribution to the recently rising emissions. But the claims of carmakers that this is the principal cause of recently rising emissions is not supported by the evidence:

- The efficiency gap between the average diesel and petrol car is small and was only 1.7 gCO_2/km in 2018, or about 1.4%.
- The 4.7g/km rise in diesel emissions since 2016 is considerably greater than that in petrol: 1.8 g/km. (Section 3.4). This worsening of average diesel emissions is largely the result of the fall in diesel market share particularly affecting smaller cars (with lower emissions) and is related to additional requirements to control real-world nitrogen oxides (NO_x) and particle emissions.

Diesel cars have much larger (on average 1.8l) and more powerful engines (by about 15%) that offset much of their inherent efficiency benefit. In contrast, petrol car engines are smaller (typically 1.35l) and have downsized between 2005 and 2015, since then they have grown again slightly. In contrast, there has been no downsizing of diesel engines since 2009. Both engines have significantly increased in power since 2009. It is notable the average petrol car has the same power as that of a diesel in 2006. A previous T&E study also highlighted diesels have high well-to-wheel emissions.

The car industry claims diesel engines are about 20% more efficient than an equivalent petrol car and the slump in sales is a major cause of the higher CO_2 emissions from new cars. But a recent study by the ICCT found that the CO_2 emissions of a petrol Volkswagen Golf were **less** than the diesel equivalent both in a laboratory test and real-world driving. Whilst diesel cars burn less fuel, each litre produces 13% more CO_2. Modern diesel engines also require fuel-intensive NOx and particle reduction technologies and are heavier than gasoline models thus offsetting some of the improvement. Diesel cars are also considerably more expensive to manufacture than gasoline engines. In the case of the two tested Volkswagen Golf versions, the December 2017 list price of the diesel vehicle was about €3,400 higher than for the gasoline vehicle - this makes dieselisation relatively expensive for compliance purposes. Diesel and hybrid models are now priced similarly but the average hybrid has emissions significantly lower emissions than a diesel (93 gCO_2/km). A comparison of the current petrol and diesel Volkswagen Golf models with other C-segment models found the emissions of the gasoline model were significantly less than other models whereas the diesel had similar emissions. This suggests there is considerable potential for carmakers to lower the CO_2 emissions from petrol cars by deploying similar technology to that used by Volkswagen.

Analysis of the most recent sales data from 2018 shows that Jaguar-Land Rover retains the highest share of diesel (81%) and that it has been relatively unaffected by the decline in diesel sales with a reduction of just 10 percentage points since 2013 (EU average of a 16 percentage point decline). On average, with 2018 figures, **for every 1% shift in the market away from diesel, the tailpipe CO_2 emissions increase by just 0.02g/km**. If the 2018 diesel and non-diesel average CO_2 emissions are mixed with the 2013 distribution, the EU average would change by just 0.25g/km. The BMW Group has been strongly affected by the diesel decline with its share of sales declining from 74% to 49% (26 percentage points but this has only raised its fleet average CO_2 emissions by about 0.5g/km). Mazda and Volvo are the only other companies with a decline of more than 20 percentage points (driving less than a 0.5g/km rise). In contrast, FCA have actually grown its share of diesel slightly to 35% in 2018.

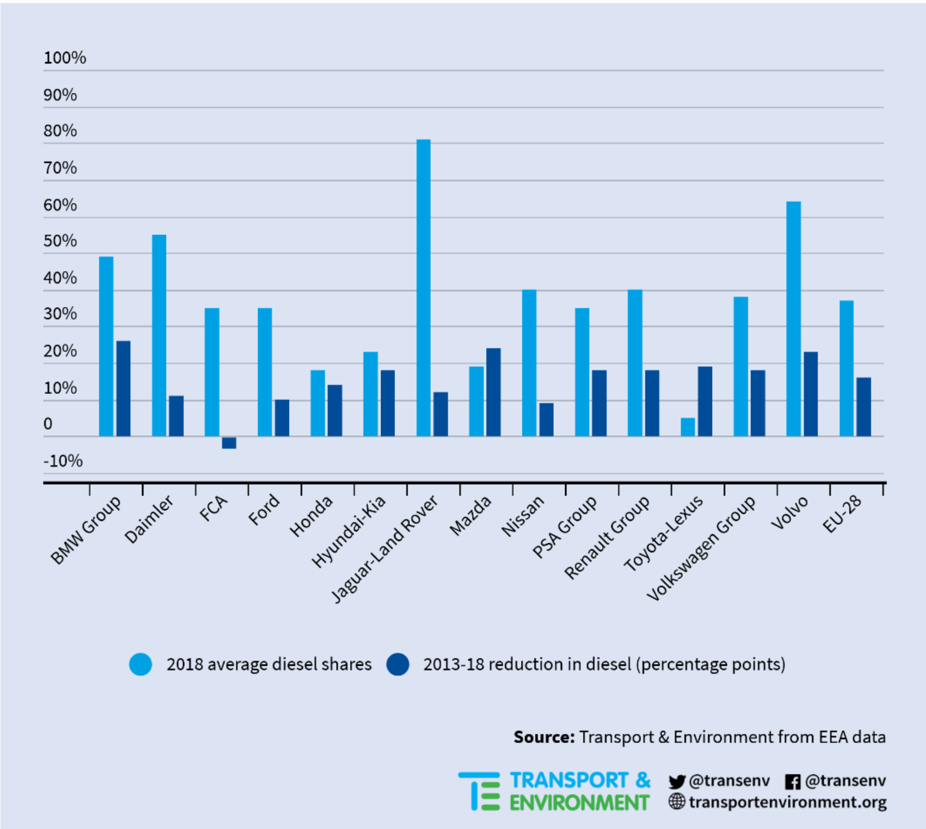


Figure 7 - Percentage diesel sales in 2018 and change in percentage share 2013-18

The share of diesel vehicle sales at a national level also varies widely across the EU. The highest shares in 2018 are in Portugal, Italy and Ireland that remain over 50%; the lowest in Finland (22%) and the Netherlands (12%) that also has the lowest average CO_2 emissions. The biggest reduction in the share of diesels sold from 2013 to 2018 have been recorded in: Lithuania (-34%), Belgium (-30%), Estonia (-28%) and France (-27%). The diesel share in Cyprus has actually risen (by 22%) and remained constant in Malta. Fuel and vehicle taxes across the EU significantly influence the take-up of diesel cars in different markets. Further information on national statistics is detailed in Annex 2.

3.2 The impact of rising SUV sales

The growth in SUV sales began in the early 2000's with sales of "Chelsea Tractors" (i.e. premium large 4x4's owned by affluent city residents) but has evolved to become a revolution in the size and shape of modern cars. More than a third of new cars (36%) are now defined as SUVs or crossovers of which: 48% are classed as Compact; 32% Small; 15% Mid-size; and just 5% Large. The additional weight and poorer aerodynamics mean these vehicles emit around 15% more CO_2 than the equivalent hatchback, but this uplift varies widely between carmakers. PSA's SUVs typically emit just 4% more than the equivalent conventional model whereas Ford's SUVs emit 23% more. SUVs and crossovers also increase the amount of land needed for parking and embedded energy and raw materials needed for construction.

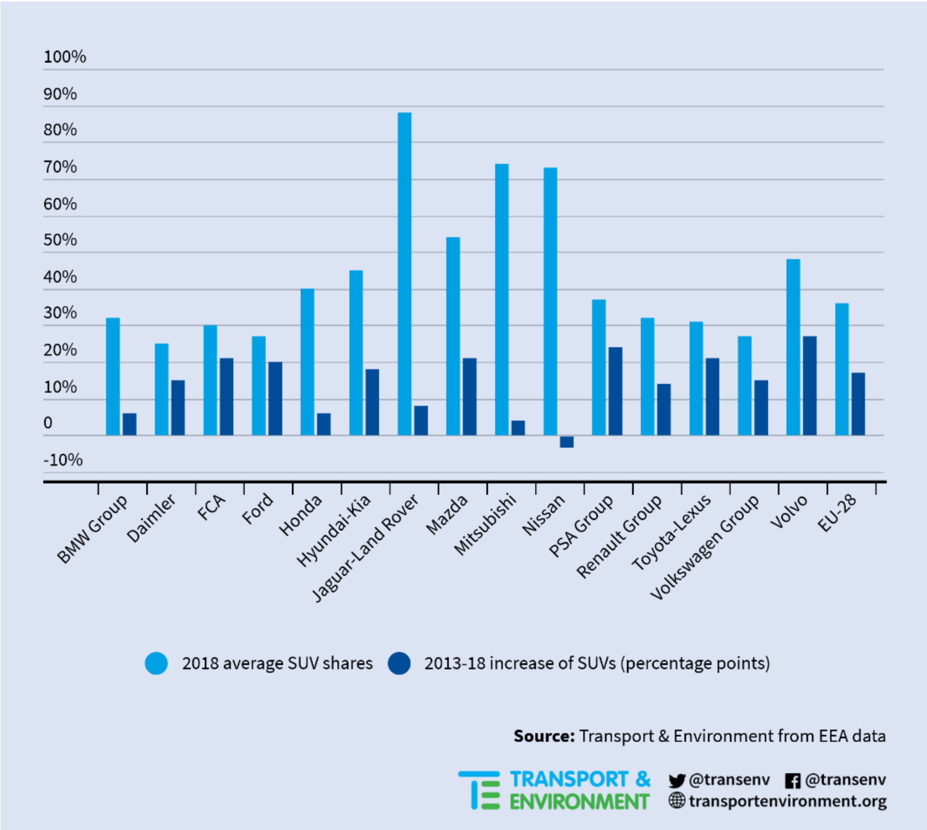


Figure 8 - Percentage SUV sales in 2018 and change in percentage share 2013-18

In the EU, 5.3 million SUVs and crossover models were sold in 2018, an increase of 18% pa. The market shift continues to accelerate with new models being continuously announced. Several companies are now doubling their model offerings in the most popular segments such as small SUVs including: Ford, Toyota, Jeep, Hyundai-Kia and Volkswagen Group. From a business perspective this is rational and profit driven, but several companies expanding SUV offers are also struggling to meet CO_2 targets and at risk of penalties, including Ford and PSA. If targets are missed and penalties incurred, carmaker's model choices and push to sell SUVs will be a contributory factor.

The rise in SUV sales has not happened uniformly across all companies. As expected, Jaguar-Land Rover has the biggest share of SUVs (88%), closely followed by Mitsubishi (74%) and Nissan (73%). The smallest share is surprisingly Daimler (25%), despite being known for its premium models. The biggest growth in SUV sales since 2013 has been achieved by: Volvo (27 percentage points), PSA Group (24 percentage points) and FCA (21 percentage points); Nissan has actually experienced a (small) decline. The overarching trend is highlighted by the EU average, with the SUV sales share doubling from 18 to 36% between 2013 and 2018. On average, from 2018 figures, **for every 1% shift in the market to more SUVs, the CO_2 emissions increase by 0.15 gCO_2/km**, **or 7.5 times more than for every 1% drop in diesel shares**. If the SUVs sold in 2018 had the 2013 market shares, the EU CO_2 average emissions would be 2.6 gCO_2/km lower.

Across the EU sales of SUVs vary widely. In Cyprus an enormous 58% of new cars sold were SUVs in 2018. Countries with more than 40% sales in 2018 were: Bulgaria, Estonia, Hungary, Ireland, Luxembourg, and

Latvia. The lowest share is in Denmark (26%). The biggest increase in the proportion of SUV sales since 2013 has been in Cyprus (+27%), and Ireland (+23%), Italy (+21%), while several countries saw an increase of 20% (Belgium, the UK, Sweden, Denmark and Greece). Notably, Greece is the country with the least improvement in overall emissions since 2013.

3.3 The impact of sales of hybrid, electric and alternatively fuelled vehicles

A shift towards alternatively fuelled vehicles, particularly increasing hybridisation of larger vehicles was one of the anticipated approaches through which carmakers were expected to achieve the targets when regulations were originally proposed in 2008. However, although there has been an increase in EVs and full hybrids, to date progress has been very limited, constrained by the choice of models and availability of supply. Whilst Toyota and Lexus have now achieved a 2018 market share of 56% hybrids and Hyundai-Kia 4.5%, no other manufacturer has chosen to supply more than 1% in recent years. The average hybrid emissions are around 93 gCO_2/km in 2018 compared to the average gasoline of 125 gCO_2/km and diesel of 121.5 gCO_2/km. The Toyota strategy has therefore been highly effective for achieving the 2020/21 targets but will not be sufficient to meet more demanding 2030 goals and will probably need to be complemented by a growing share of EVs for 2025 (which the company recently announced).

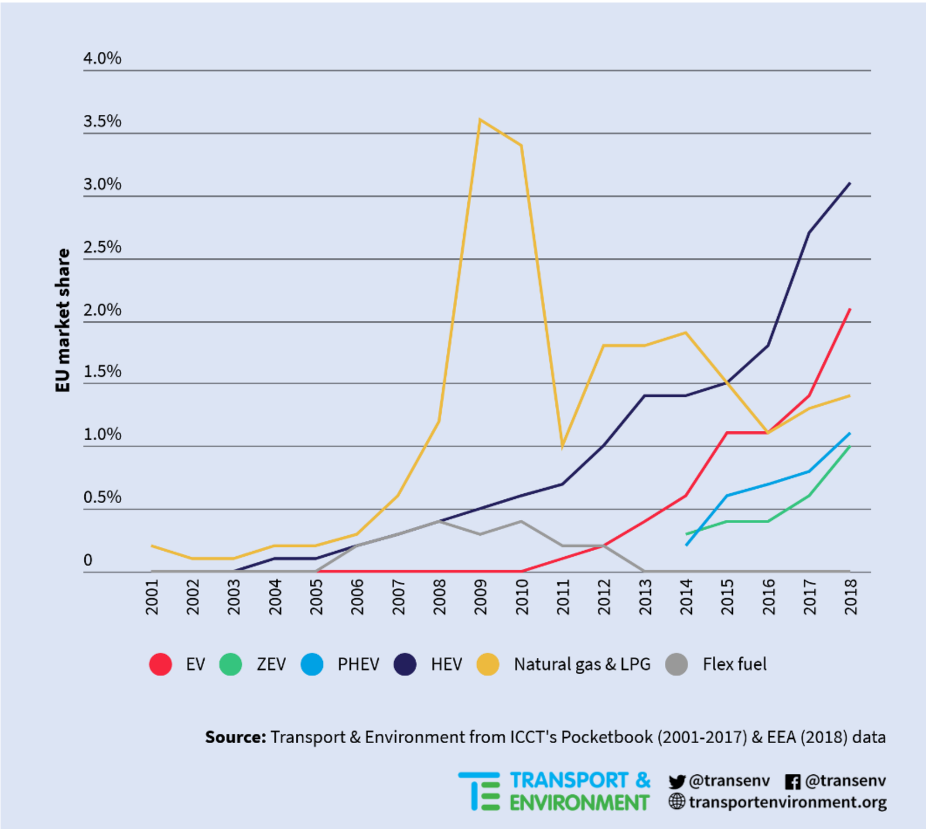


Figure 9 - Trends in sales of alternatively fuelled cars

Other alternatively fuelled vehicles such as natural gas and flex fuel cars do not deliver significant CO_2 savings but have fared even worse in terms of sales. Natural gas and LPG cars peaked at 3.7% in 2009 but now represent just 1.4% of the market. FCA, Opel and Volkswagen Group have the biggest market shares and notably both are struggling to achieve the CO_2 targets. Flex fuelled cars actually disappeared entirely in 2013 with Saab. The trend in sales of alternatively fuelled cars is shown in Figure 9.

Sales of EVs are now growing strongly but from a low base. The increasing EV sales is the most likely compliance path for most carmakers to achieve targets. Sales of all EVs reached 2% in 2018 (2.7% in the final quarter, up 38% in year). Availability of models remains a huge constraint (but is expected to grow significantly) along with the cost of cars and concerns there are insufficient charging points. The market shares of different manufacturers for EVs indicate which companies are best placed to grow sales to achieve targets. Nissan together with Mitsubishi is the clear market leader overall with both ZEV and PHEV models reaching 8% sales of EVs in 2018, closely followed by BMW Group (6.7%) and Volvo (6.4%) (even though the Swedish manufacturer has relied so far on plug-in hybrid technology only). Jaguar-Land Rover (4.3%), Hyundai-Kia (3.2%), Daimler (2.9%) and Renault Group (2.2%) are similarly well placed; the Korean group being the only carmaker with a balance of ZEV, PHEV and HEV sales. Other companies need to rapidly increase the offering of EVs to lower emissions and achieve targets, of these Volkswagen Group with ambitious plans seems the best placed for this to be an effective compliance strategy.

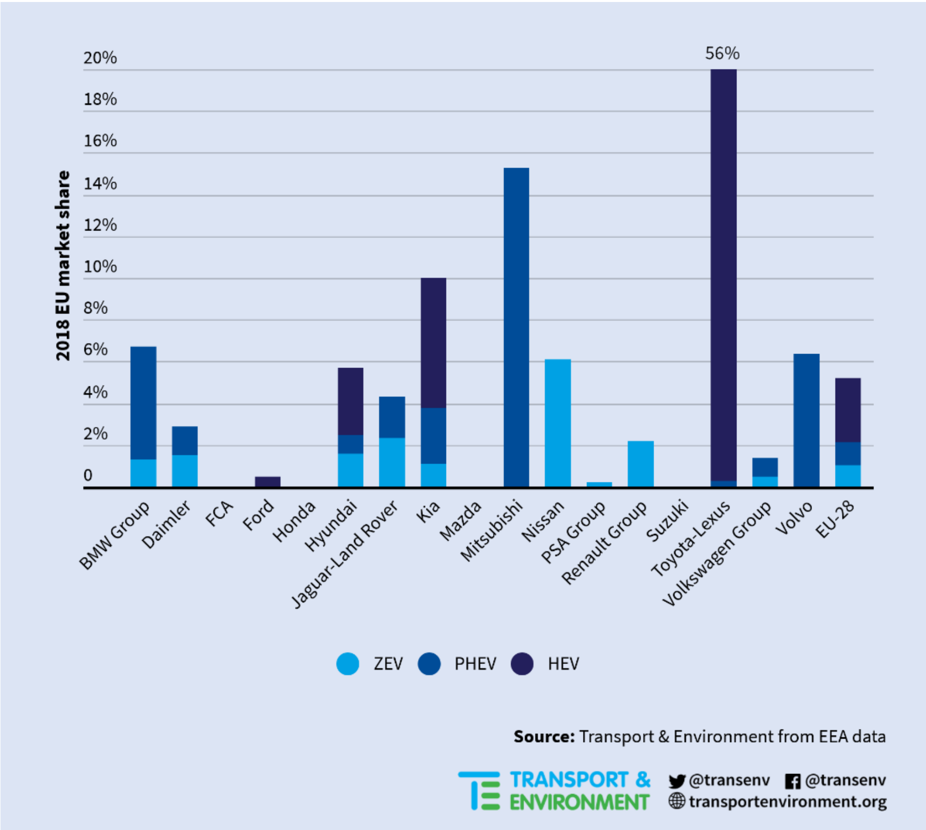


Figure 10 - Company sales of ZEV, PHEV and HEV cars in 2018

At a national level there are wide variations in the proportion of EVs sold. The highest share of electric cars in total (PHEV and ZEV) in 2018 in the EU was achieved in Sweden (8.4%) and the Netherlands (6.8%). Both countries have supportive taxations systems. Norway achieved much higher levels (49%) of which 31% were ZEVs. Norway has recently joined the CO_2 regulation so electric cars sold there will count towards EU targets in 2020/21. The biggest share of ZEVs in the EU was the Netherlands (5.9%) and that for PHEV Sweden (6.4%).

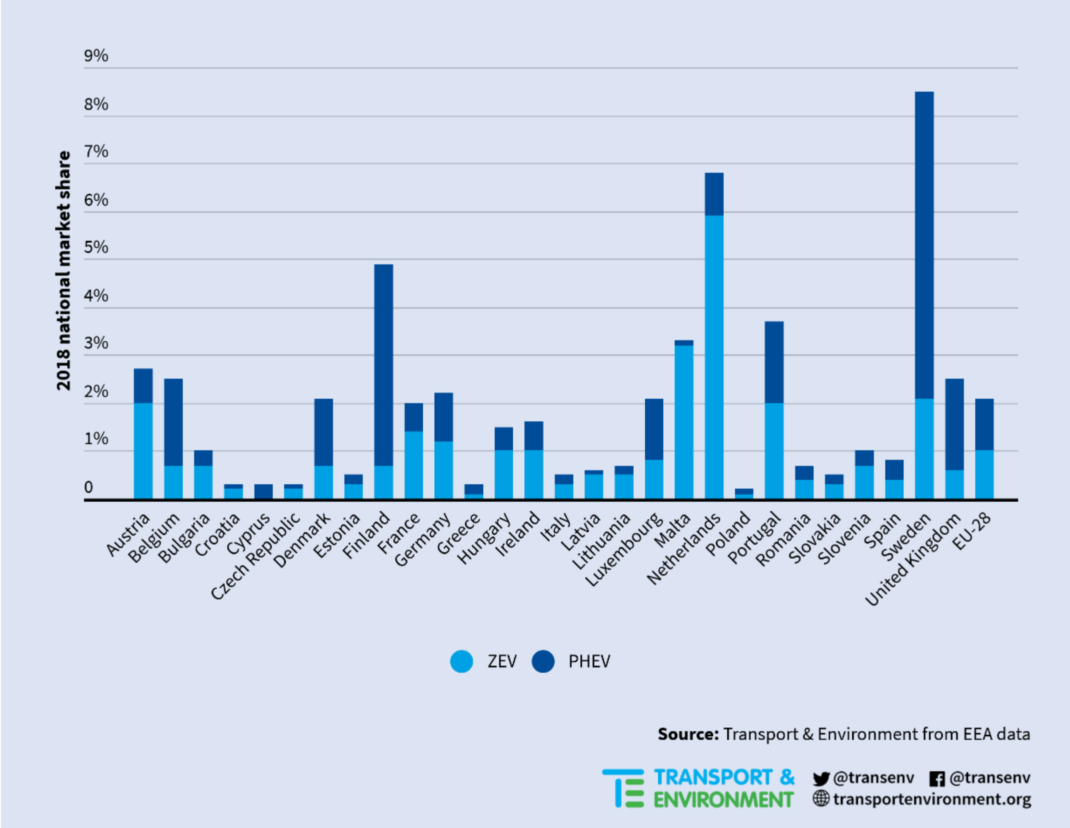


Figure 11 - Sales of electric cars in EU countries

Section 4 examines the number of EVs that are likely needed to be sold to achieve targets.

3.4 The impact of improvements to ICE emissions

One of the key compliance mechanisms available to carmakers is to improve the efficiency of the conventional (ICE) cars being sold. This could include fitting of low rolling resistance tyres, improved lubricants, mild hybrid technology (full hybrid systems are considered in Section 3.3); cylinder deactivation; light-weighting, improved and better calibrated diesel and petrol engines and a range of other solutions. T&E examined changes in the emissions of conventional petrol and diesel vehicles since 2013. The analysis showed is summarised in Figure 13. There has been very limited improvement in emissions from conventional ICE cars in recent years. Since 2013, emissions from petrol vehicles declined by just 4.9 gCO_2/km and those from diesels decreased by 5.3 gCO_2/km. But the overall trend marks wide ranges between different companies.

Figure 12 - Examples of technologies fitted on Volkswagen's new 1.5-litre petrol engine

The latest 1.5-litre petrol engine launched by the Volkswagen Group, available for instance on the current Golf VII model, emits on average 115 gCO_2/km (according to EEA's 2018 database) with two power levels offered (96 and 110kW), while the 1.4-litre petrol engine it replaces emits on average 121 gCO_2/km with a power level of 92kW. This average improvement of 6 gCO_2/km on the same model and with similar engine power has been possible thanks to a package of engine technologies that are far from being mainstream on petrol engines (yet) and include: a Miller cycle that increases thermodynamic efficiency (usually used on full hybrid petrol engines), variable-geometry turbocharger (mainstream on diesel engines but not on petrol engines), a direct injection system with a high fuel pressure of 350 bar while the current standard for direct injection petrol engines is about 150-200bar; and also cylinder deactivation. Volkswagen is showing the huge potential to lower petrol engined emissions that is currently largely unexploited.

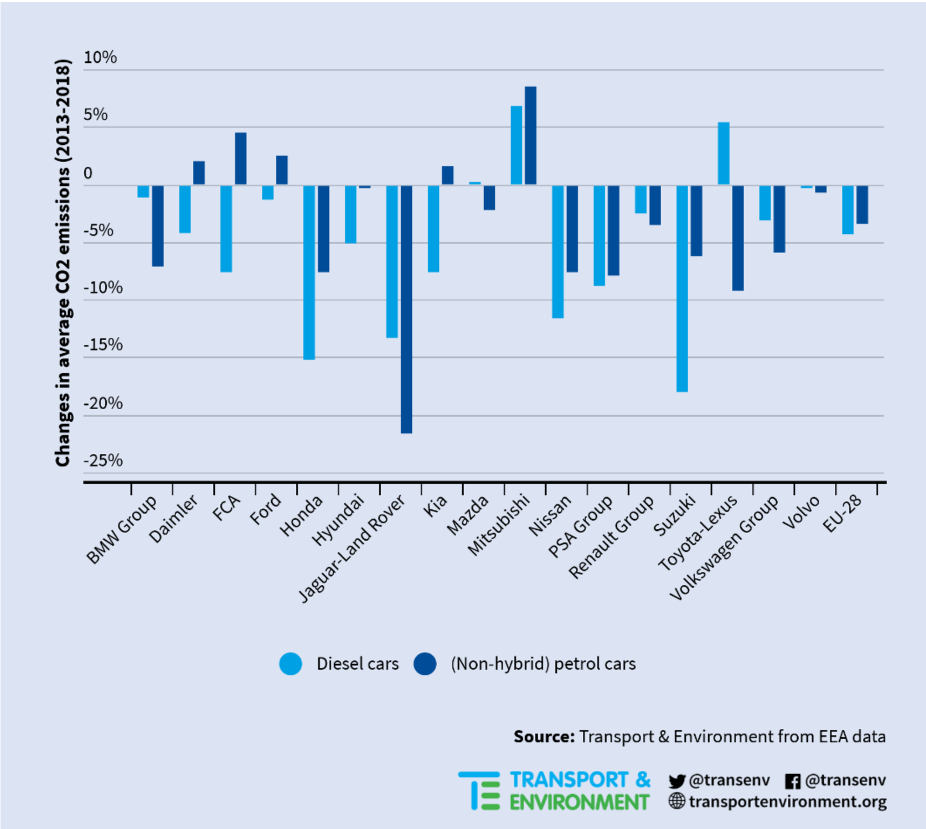


Figure 13 - Percentage change in average petrol and diesel emissions by company 2013-18

3.4.1 Eco-innovations

Eco-innovations are another compliance mechanism that can reduce a few g/km of CO_2 from conventional ICE vehicles. In 2018, the use of eco-innovations was minimal (3.6% of 2018 registrations), reducing the CO_2 average emissions by just 1.5 gCO_2/km considerably less than the 7.5 gCO_2/km allowed. The two most widely deployed eco-innovations are efficient alternators (that are fitted to about three-quarters of models to which eco-innovations are deployed, each saving on average 1.5 gCO_2/km); and LED lamps fitted to a quarter of cars with eco-innovations saving on average 1.1g/km each. A small proportion of models have both technologies saving on average 2.7 gCO_2/km each. Underutilised eco-innovations that could deliver significantly higher savings include:

- engine encapsulation (that keeps the engine warm reducing the additional fuel used during cold starts) and which lowers emissions by 1.4 gCO_2/km on average per vehicle on which it is deployed; and
- coasting (a technology to reduce fuel use on highways) which saves 5.4 gCO_2/km on average on each model.

By 2021 it is estimated the use of eco-innovations will double to around 3 gCO_2/km.

3.5 Effects of changes to tests

Section 2.1 outlined the significant differences between the improvement in new car CO_2 emissions measured using the NEDC laboratory test and real-world emissions. The growing gap has offset 21 gCO_2/km of the real improvement in new car CO_2 emissions but has not affected compliance with the regulation that is based upon the NEDC test. There are however other changes to testing that do have an effect upon the effective stringency of the regulation.

The introduction of the new WLTP test is not expected to have any significant effect until 2021, as the regulation specifying how to adapt the 2020/21 CO_2 targets for the WLTP test allows carmakers to double test cars using both the NEDC and WLTP procedures (an approach that is expected to be widely used). However, changes to the NEDC test procedures (referred to as NEDC 2.0) were introduced to eliminate the most egregious abuses of the NEDC test. Specific changes include changes to the test parameters to ensure the correct inflation of tyres by requiring the pressure to be between the manufacturers prescribed range. Minimum allowed tyre tread depth has also been altered to be consistent with the WLTP regulation (an average difference of 2mm is assumed from WLTP requirements). A more correct methodology to determine the road load coefficients from measurements on sloped test tracks is also now used. Regarding the lab test itself, the ambient temperature is specified to be at 25°C instead of a range of 20-30°C. The cumulative impact of these changes is estimated to be about a 5% increase in NEDC test results and reduces the gap between test and real-world performance making achieving the target marginally more challenging. This change is nonetheless small compared to the widening gap created by test abuses. This effect is not accounted for in T&E's assessment of the way carmakers will achieve their targets.

4. Compliance options

4.1 Progress to 2018

This section looks at the progress of individual companies and possible compliance strategies to achieve 2020/21 targets. Figure 14 shows for each carmaker group the 2018 gap to close with the 2020/21 CO_2 targets. The gap with the 2021 targets is the difference between the 2018 average CO_2 value and the target; the gap with the 2020 targets is the difference between the 95th percentile of 2018 CO_2 performance and the target.[3] Data tables are provided in Annex 4. EU-28 data is analysed and the effects of Brexit not considered but small. The companies are listed in order of their gap to the 2020 target. The company targets vary depending on the average mass of the vehicles sold so companies selling larger and heavier cars have a higher goal. There is a derogation for companies selling less than 300 thousand cars that particularly benefits Jaguar-Land Rover.

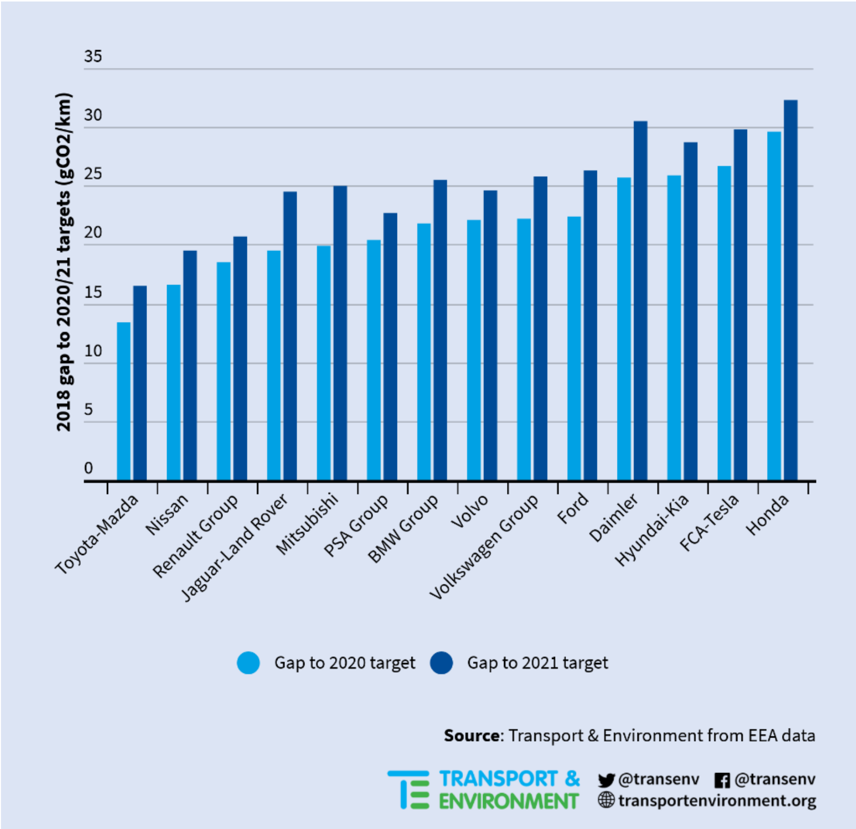


Figure 14 - Company progress to 2020 and 2021 targets[4]

Figure 14 shows that the company with the largest gap to close by 2020 is Honda (30 gCO_2/km). The companies with the smallest gap are Toyota-Mazda (13 gCO_2/km), Nissan (17 gCO_2/km) and the Renault Group (18.5 gCO_2/km). The size of the gap illustrates the scale of the remaining challenge. If this gap was to be closed exclusively by sales of EVs it would require an EU market share of about 24% by 2021. However, this section highlights several compliance approaches that when used in combination can reduce the EV take-up to more realistic levels in the next 2 years.

[3] In 2020, 95% of all new car sales must reach the required target to avoid penalties, the 5% of highest emitting cars being excluded. In 2021, 100% of sales are counted towards the target.

[4] The graph presents data for company groups including where companies have agreed to pool outside of the group. In some cases, these do not correspond to the current pools being used by the manufacturer within the regulation. For example, Hyundai and Kia are currently treated separately in the regulation but are pooled here for presentational purposes. More information on the considered pools in T&E's model can be found in Annex 1.

Most companies (BMW Group, Daimler, FCA, Jaguar-Land Rover, Renault Group, Volkswagen Group and Volvo) have followed a similar trend in recent years with rising emissions since 2016. The rise for Volvo to 132 gCO_2/km is particularly large creating a significant challenge for the company. Volvo has a high share of both diesels and SUVs. For Ford and Mazda, emissions have been rising for 3 years. Toyota and Honda have maintained a consistent decline since 2016 year on year. This is despite Toyota diesel sales shrinking from 25% in 2014 to just 5% in 2018, illustrating the success of its hybrid strategy.

4.2 Compliance options and regulatory flexibilities

There are three principal strategies carmakers can deploy to lower emissions and achieve their targets:

1. Selling more zero emission and plug-in hybrid cars with significantly lower CO_2 emissions (this is also the best long-term compliance strategy beyond 2020/21). Cars with emissions below 50 gCO_2/km (battery, fuel cell and most PHEVs) earn super-credits until 2022 and help carmakers hit the CO_2 targets.

2. Lowering CO_2 emissions of conventional diesel and petrol cars being sold through fitting additional technologies to improve efficiency. This can include fitting mild and full hybridisation to more models, as well as improving tyres rolling resistance and engine efficiency, e.g. the package found on Volkswagen's new 1.5-litre petrol Golf. Technologies can lower emissions either in the test or on the road (eco-innovations). Hybridising conventional engines, in particular on larger SUV models, stands out as having good potential (albeit short-term) to meet the 2020/21 targets as shown by Toyota.

3. Selling more lower emissions/power diesel and petrol models and fewer high emitters as a short-term strategy through marketing and pricing strategies & incentivising dealers (e.g. selling a petrol Volkswagen Golf version with a lower 85 kW engine rather than today's more popular high power version of 96 or 110 kW). On average, encouraging 20% of customers to shift to a smaller or less powerful engine will typically deliver about 1.6 gCO_2/km reduction in fleet average emissions. A variation of this is to withdraw the highest emitting models (or engines) from sale, e.g. some high performance cars such as sold under the Mercedes' AMG or BMW's M ranges. Withdrawing the 5% of highest emitting models achieves a further CO_2 reduction of about 2% on average (e.g. 2.5 gCO_2/km less CO_2 for 2018).

Each approach has costs either in terms of additional technology and manufacturing costs or lower margins (as high emission models achieve higher margins). But the cost of compliance is estimated to be much less than half that of the penalty of €95 per gCO_2/km per vehicle sold. According to Evercore, based upon discussions with carmakers, the total cost of CO_2 compliance with 2020/21 targets is between €40/g and €60/g[5] from a 2018 baseline. (The higher figure is unlikely to be an average cost).

In addition to these compliance strategies, the regulation also includes numerous flexibilities to help carmakers achieve their goals. This includes pooling (combining targets between brands) - an approach successfully deployed by FCA that has linked up with Tesla; as well as Mazda that will pool with Toyota that will overachieve its targets. Whilst there is unquestionably a cost to those companies buying credits, there is also a revenue for those over achieving their targets. Many companies are also pooling within their groups.

Super-credits, double counting of cars with emissions below 50 gCO_2/km sold in 2020 (the factors are 1.67 and 1.33 in 2021 and 2022 respectively) can also significantly help carmakers achieve their goals. Up to 7.5 gCO_2/km of credits can be used towards targets between 2020 and 2022 and most companies are anticipated to make use of this flexibility. Another important flexibilities in the regulation are eco-

[5] Evercore ISI, Global Automotive, CO_2 – The biggest structural 2020/21 headwind, April 2019

innovations. The switchover to the WLTP test will also have no significant impact as carmakers are permitted to double test vehicles on the NEDC test. The inclusion of Norway into the regulation will also assist carmakers achieve their goals as almost 50% of roughly 150k cars sold in Norway are EVs, helping companies lower average emissions and earn super-credits through selling EVs in Norway.

4.3 Assessment approach

In order to evaluate whether carmakers will be able to comply with the regulation; and how many EVs they need to sell in order to do so; T&E assessed to what extent improvements in conventional vehicles; and altering the sales mix to lower CO_2 models can close the gap. We then calculated the number of EVs needed to meet the target and reviewed whether this was feasible compared to current sales and planned production (using another database from IHS Markit). This gives a good indication of which companies are at greatest risk of non-compliance.

How much carmakers plan to invest in improving the efficiency of ICEs is not fixed and neither is the degree to which they intend to encourage customers to buy lower emission models. The analysis therefore estimated the number of EVs the carmaker would need to sell assuming a Business as Usual (BaU) approach and a series of scenarios in which companies put more or less dependence on selling EVs as against the other options to meet the target. Table 1 below summarises the compliance plan scenarios.

	Business as Usual	Plan 1	Plan 2	Plan 3
EV sales required	EV Max	EV High	EV Central	EV Low
Conventional Technology Investment	€20/ g/km	+10% BaU	+20% BaU	+20% BaU
Sales Shift	None	None	20% of customers choose lower CO_2 model	20% of customers choose lower CO_2 model
Discontinuing high emitting models	None	None	None	Highest 5% of variants discontinued

Source: Transport & Environment

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table 1 - Description of the different scenarios used in T&E's model

Further details of the modelling approach are detailed in Annex 1. To estimate the improvement in ICE vehicles that was possible, T&E looked at the reduction in CO_2 these models achieved over the period 2013-18 and then used cost-curves developed by the European Commission to estimate the level of spend this would equate to. For the BaU scenario, this investment was continued and for other compliance plans a higher spend rate for 2013-21 was applied.

To estimate the impact of the sales shift, T&E examined the impact of one in five customers downsizing to the next smaller engine or power variant. By doing this, they are helping the carmaker achieve its targets by shifting to a lower CO_2 model. This can be achieved relatively easily by pricing differentials (placing a higher cost on the higher CO_2 model and lower one on the lower CO_2 option); and by incentivising dealers to sell lower CO_2 models through their bonus and dealership targets. This has a small impact on CO_2 but could help achieve some targets.

The impact of ceasing sales of the highest emission models was determined by calculating the difference between the fleet average emissions of the 95^{th} percentile and 100^{th} percentile for cars sold in 2018.

Based on these 3 factors a business as usual and 3 compliance plans were developed, each with a different number of EVs required to meet the company target. The plans are:

1. **Business as Usual** - Carmakers continue to lower CO_2 emissions from conventional powertrains (i.e. diesel, petrol, full hybrids) at the same level as done until 2018 (per segment and fuel type - the EU average is around €20/gCO_2). This means CO_2 emissions from conventional vehicles fall through use of, for instance, low rolling resistance tyres, cylinder deactivation, mild-hybridisation, etc. However, the investment is restricted and technologies therefore deployed on a limited range of models. The remaining gap to targets is met exclusively through selling EVs. For each company the ratio of PHEV to ZEV is based upon IHS's production mix for 2020/21.[6] This is the most conservative scenario and corresponds to the maximum share of EVs the company needs to supply to meet goals. This is the preferred plan if the company is able to achieve its targets.

2. **Plan 1 - EV High -** with this option carmakers increase investment in conventional powertrains raising spend between 2013-2021 by 10% compared to what has been spent from 2013 to 2018. This means larger deployment of conventional lower emission technologies including more expensive technologies fitted to more vehicles than for Business as Usual and therefore fewer EVs are required to achieve targets than for BaU. Companies able to supply relatively high shares of EVs may adopt this plan minimising spend on conventional technologies.

3. **Plan 2 - EV Central -** with this option carmakers increase investment in conventional powertrains raising spend by 20% compared to what they spent up to 2018, plus take steps to alter the sales profile of their best selling models towards lower emissions variants so that 1 in 5 customers buy a smaller or less powerful engine (e.g. selling a Volkswagen Golf with an 85 kW engine instead of the 96 or 110 kW option). In practice, this means a carmaker makes their smaller/lower emitting car models more attractive via lower price or via increasing prices on higher emitting/more powerful models.

4. **Plan 3 - EV Low** - with this option carmakers increase investment in conventional powertrains raising spend by 20% compared to what they spent up to 2018 (as for Plan 2) plus taking steps to alter the sales profile of their best selling models towards lower emissions variants so that 1 in 5 customers buy a smaller or less powerful engine (as for Plan 2). In addition, carmakers withdraw from sale the highest 5% emitting variants. These are typically low volume, high margin models such as cars in BMW's M series or Mercedes' AMG. Through focusing on bringing down ICE emissions, carmakers can minimise sales of EVs needed to achieve targets so this represents a low case for EV sales. This case will be followed by companies unable to supply EVs in significant number and those of greatest risk of incurring penalties.

The analysis provides an indication of future EV sales by company and overall. The model also takes into account anticipated increases in SUV sales; further declines in diesel sales; some increase in hybrid sales; and anticipated use of eco-innovations and super-credits (where these are earned) and anticipated pools. In this way, the assessment presents a realistic picture of the likely EV market. The number of EVs is ZEVs plus PHEVs. The proportion of each varies between companies depending upon planned production (and this influences the number of EVs they need to sell). For example, Volvo has a very high share of EVs in part because 90% of future EVs production is anticipated to be PHEVs with emissions just below 50 gCO_2/km, not 0 gCO_2/km ZEVs.

[6] More details about this assumption can be found in Annex 1.

4.4 Compliance with 2020 targets

The following table shows the results of the analysis for the baseline and the 3 compliance plans for 2020.

CO_2 pools	2018 EV sales	ZEV/PHEV mix	Business as Usual	Plan 1	Plan 2	Plan 3
BMW Group	6%	34%/66%	15%	11%	6%	3%
Daimler	1%	57%/43%	16%	12%	7%	4%
FCA-Tesla	2%	53%/47%	12%	8%	3%	2%
Ford	0%	0%/100%	12%	6%	1%	0%
Honda	0%	100%/0%	17%	15%	11%	10%
Hyundai-Kia	3%	58%/42%	12%	9%	3%	2%
Jaguar-Land Rover	4%	45%/55%	16%	11%	6%	2%
Mitsubishi	15%	0%/100%	22%	17%	11%	8%
Nissan	6%	83%/17%	13%	9%	3%	2%
PSA Group	0%	41%/59%	8%	4%	1%	0%
Renault Group	2%	79%/21%	9%	5%	2%	1%
Toyota-Mazda	0%	14%/86%	0%	0%	0%	0%
Volkswagen Group	1%	64%/36%	11%	8%	3%	2%
Volvo	6%	8%/92%	23%	19%	14%	11%
EU average	**2%**	**48%/52%**	**11%**	**7%**	**3%**	**2%**

Source: Transport & Environment

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table 2 - Progress to targets for 2020

Progress to 2020 targets

The 2020 target analysis reveals:

- Toyota (and Mazda) will comfortably achieve the 2020 target with Business as Usual;
- FCA (with Tesla), BMW Group, Hyundai-Kia, Mitsubishi, Nissan and Renault Group (that includes Dacia) should be able to achieve their targets with the close to current EV sales and some investment in efficient technology alone.
- With some investments in efficiency improvements and significant but achievable growth in EV sales: Daimler, Ford, Jaguar-Land Rover, PSA Group and Volkswagen Group will meet their targets. If these companies are unable to supply or sell higher numbers of EVs, they need to make extra effort to incentivise customers to choose less emitting and less powerful conventional models.
- From the modelling, Honda and Volvo will need to sell more than 10% EVs or adopt very strong measures indicated in Compliance Plan 3. Honda currently have no sales but one ZEV and one PHEV model planned. Volvo have PHEVs (and one ZEV model coming) but need a high share of EVs (14%). Volvo intends to offer most of its premium cars as plug-in hybrid versions, rather than gasoline, and assuming customers are attracted to these vehicles in large numbers, Volvo will not receive penalties.

4.5 Compliance with 2021 targets

The below table shows the results of the analysis for the baseline and 3 compliance plans for 2021. The 2021 target analysis reveals:

- Overall, the level of EV sales required to achieve targets are higher in 2021 than was needed in 2020. This is primarily because the majority of super-credits have been utilised in 2020 (up to 5g), and is an indication of how far the industry has fallen behind where it needs to be.
- Toyota (and Mazda) will comfortably achieve the 2021 target with just business as usual.
- With the assistance of Tesla and some efficiency improvement, FCA should achieve its target easily.
- Hyundai-Kia, Mitsubishi, Nissan, PSA Group and Renault Group could achieve targets with the planned growth in EV sales and some efficiency improvements for ICE, but may also need to incentivise customers to choose less powerful and lower emitting conventional models if EV production is delayed or sales weaker than hoped.
- Premium manufacturers such as BMW Group, Daimler, Jaguar-Land Rover and Volvo will probably need to follow Compliance Plans 2 or 3 to achieve targets unless they are able to considerably increase EV sales.
- If Volkswagen Group can achieve 10% EV share, it will be able to achieve its target only through a modest efficiency improvement. However, even small reductions below this level requires other aggressive compliance plans.
- Honda, Jaguar-Land Rover and Ford are at greatest risk of incurring penalties.

CO_2 pools	2018 EV sales	ZEV/PHEV mix	Business as Usual	Plan 1	Plan 2	Plan 3
BMW Group	6%	41%/59%	20%	16%	11%	8%
Daimler	1%	62%/38%	21%	18%	12%	10%
FCA-Tesla	2%	54%/46%	17%	13%	8%	5%
Ford	0%	0%/100%	18%	13%	5%	3%
Honda	0%	82%/18%	19%	16%	12%	11%
Hyundai-Kia	3%	59%/41%	16%	13%	7%	5%
Jaguar-Land Rover	4%	43%/57%	23%	19%	13%	10%
Mitsubishi	15%	0%/100%	29%	24%	18%	16%
Nissan	6%	46%/54%	20%	16%	9%	6%
PSA Group	0%	47%/53%	13%	8%	3%	2%
Renault Group	2%	66%/34%	14%	10%	5%	3%
Toyota-Mazda	0%	16%/84%	1%	0%	0%	0%
Volkswagen Group	1%	63%/37%	17%	13%	8%	5%
Volvo	6%	10%/90%	27%	23%	19%	16%
EU average	**2%**	**48%/52%**	**16%**	**12%**	**7%**	**5%**

Source: Transport & Environment

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table 3 - Progress to targets for 2021

Assessing compliance approaches is inherently uncertain and requires a large number of assumptions. The approach T&E has used assumes the targets will be met and then calculates the number of EVs that need to be sold to do this. If the sales are too high, the company is judged as being at risk of penalties. However, some companies will choose to invest more in efficient technology to lower ICE emissions, others could try to shift more buyers to lower CO_2 engine variants as alternative approaches to compliance. Despite the inherent uncertainties, T&E believes the data provides a good indication of the small number of companies at risk of penalties and the number of EVs that need to be sold to achieve targets.

4.6 Comparison of planned production and sales requirements

To provide a better indication of which compliance scenario the company is likely to follow and whether it is at risk of incurring penalties, the required sales data presented above has been compared against planned EV production data that T&E acquired from IHS Markit and used in a previous study. This assumes that the planned production for 2020 and 2021 will in fact be delivered; and requires a range of assumptions including that production in Europe is intended for sale in Europe and for companies largely importing in the EU market, there will be a sufficient share of EV production sent to Europe. Figure 15 shows the comparison of planned EV production and required EV sales for each company for each compliance plan for 2020 - by estimating the % difference between the planned production and the different EV shares, which is either positive (i.e. enough production planned) or negative (not enough EVs planned to be produced). Figure 16 presents the same data for 2021. The simple interpretation of the figures is that a positive bar indicates the company has planned sufficient EV production to meet the target for the specific compliance scenario.

For 2020, the comparison confirms Toyota (with Mazda) and FCA (with Tesla) can achieve the targets following EV-Max - Business as Usual. Daimler, Jaguar-Land Rover, Nissan, PSA Group, Renault Group, Volkswagen Group and Volvo (with BMW Group very close) all have sufficient planned production to comply following the High EV Compliance Plan 1. All other companies comply using Compliance Plan 2 - Central EV scenario. The graph shows Honda does not have sufficient EV production planned to realistically achieve the target for any compliance plan. However, Honda is planning the launch of hybrid vehicles to bring down its fleet average emissions, which is not included in the current analysis. Assuming that Honda sell a sufficient number of these vehicles, they will comply with the regulation and avoid penalties.

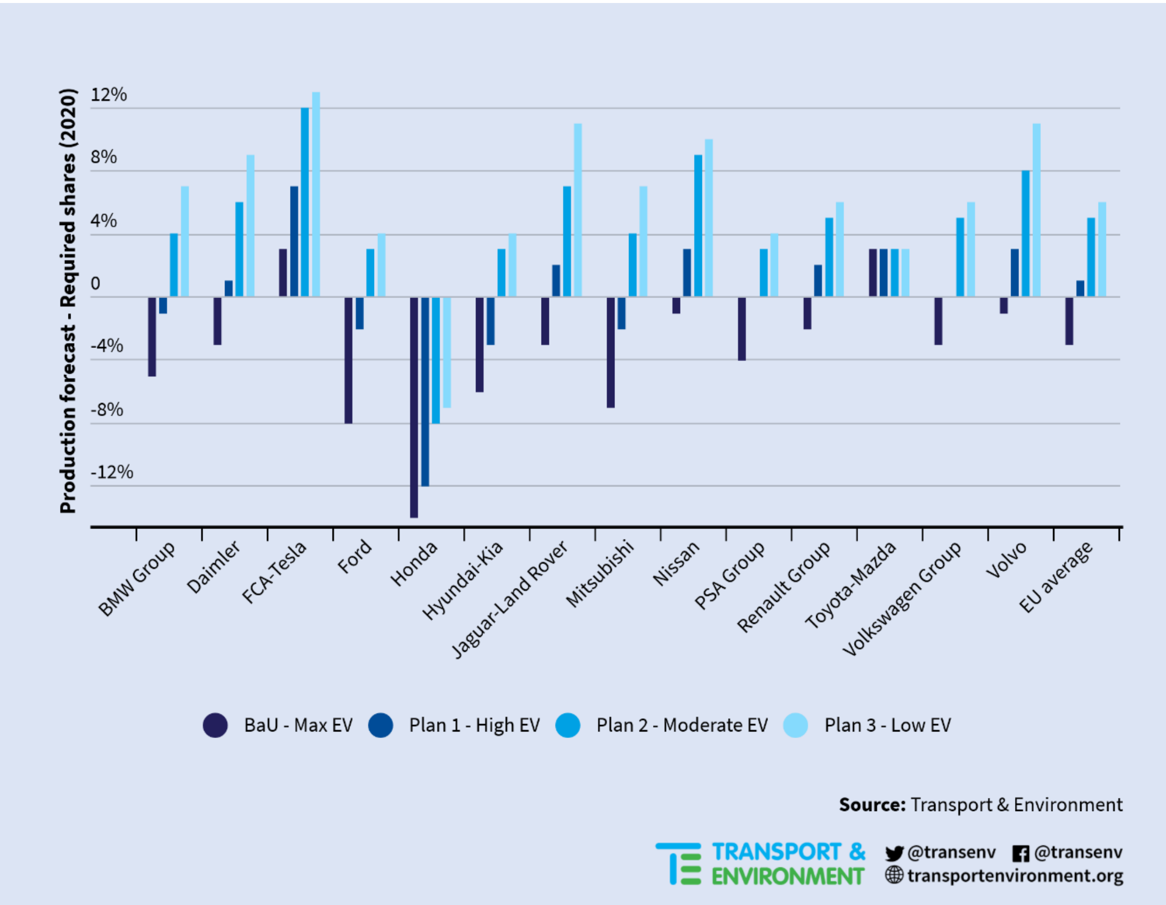


Figure 15 - Comparison (in percentage point difference) of planned production of EVs and required sales for 2020

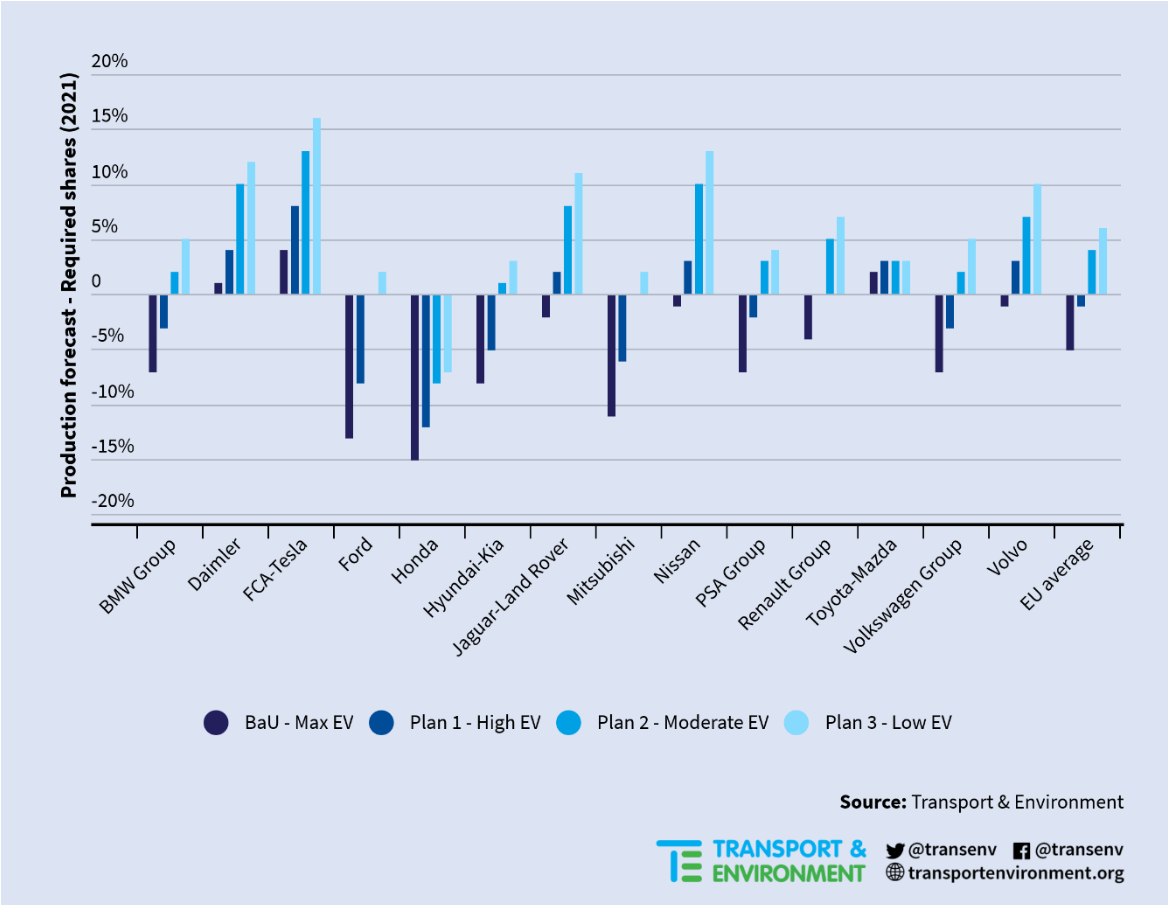


Figure 16 - Comparison (in percentage point difference) of planned production of EVs and required sales for 2021

For 2021, Daimler, FCA-Tesla and Toyota-Mazda could achieve targets using the Business as Usual compliance plan - EV max. Jaguar-Land Rover, Nissan, PSA Group, Renault and Volvo all comply with Plan 1 - EV High. BMW Group, Ford, Hyundai-Kia, Mitsubishi and Volkswagen Group have lower EV production planned than is needed to comply with Plan 1 (so comply through Plan 2 - Central EV). BMW Group and Volkswagen Group can comply with Plan 1 if they are able to increase EV production by another 3% percentage points. Honda is again an outlier but can still comply if its hybrid strategy is successful.

The analysis confirms that so long as the planned production is not delayed there will be sufficient EVs produced to meet the targets and avoid penalties. Of course, the cars also need to be sold and this is considered further in Section 5.

5. Conclusions and Policy recommendations

5.1 Why carmakers made so little progress

To avoid a climate emergency, quickly reducing and fully decarbonising new car sales by 2035 at the latest is essential. New car CO_2 regulations are a key policy to change the car fleet requiring the car industry to progressively lower the CO_2 emissions from new cars and supply zero and low emission models. Complemented by other policies to reduce car trips and ownership, use of personal transport can be decarbonised. But to date regulations have had a very limited effect on new car CO_2 emissions on the road for the past 25 years, reducing emissions by just 0.8% pa. An ineffective voluntary agreement, weak 2015 targets and loopholes in testing have all contributed to the failure to significantly lower on road car CO_2 emissions. Coupled with steadily rising mileage car emissions overall are still growing.

The 2020/21 new car CO_2 targets, proposed over 10 years ago, are intended to achieve a step change in car emissions. But the overall rise in new car CO_2 emissions since 2016 and the resulting 25 gCO_2/km gap that still needs to be closed overall between 2018 sales and the 95 gCO_2/km 2020/21 target is a considerable challenge for carmakers. When the regulation was originally adopted in 2009, carmakers needed to reduce emissions by around 50 gCO_2/km - but just a year before sales count towards targets, carmakers had halved the emissions of the required total. The gap to close primarily arises for 3 reasons:

1. There has been very limited improvement in emissions from conventional ICE cars in recent years. Since 2013 emissions from petrol vehicles declined by just 4.9 gCO_2/km and those from diesels decreased by 5.3 gCO_2/km.
2. To date, supply of zero and low emission vehicles has been very poor (with the notable exception of hybrids by Toyota).
3. SUV sales have grown from 7% in 2009 to 36% in 2018, coupled with an increase in vehicle power and weight. For every 1% shift in the market to more SUVs, the CO_2 emissions increase by 0.15 gCO_2/km on average.

The decline in diesel has only had a small effect increasing emissions by 0.02g/km for every 1% decline in diesel sales. Overall, the diesel decline is therefore affecting emissions 7.5 times less than the SUV rise.

The size of the gap to close varies between carmakers, with Toyota best placed to be able to reach its 2020 target with a gap of 13 g/km. The Renault-Nissan-Mitsubishi Alliance is also very well placed. The companies with the largest gap to close are Honda (30 g/km), Hyundai-Kia, Daimler and Volvo. Fiat-Chrysler also has a large gap but following their pooling with Tesla is comfortably placed to achieve its target. The 2020 target was agreed a decade ago and carmakers could have gradually phased in the necessary changes (as Toyota has done). Instead, carmakers have chosen to pursue short-term profit focused strategy, delaying the necessary investments until the last possible moment. The time available to make the necessary improvements to ICE vehicles and put in place the new production for EVs is now extremely tight with sales of cars that count towards the 2020 target beginning in less than 4 months. There can be no more delays if penalties are to be avoided.

The cost of the penalties are likely to be considerably higher than the costs of complying. The penalties incurred for failing to achieve targets have been set at a cost of €95/vehicle/gCO_2/km. The current gap to meet targets is on average 25 gCO_2/km so carmakers could (theoretically) invest up to €2,375 per vehicle before the costs outweigh the penalties. In practice, however, the costs will be much lower than this. The assessment shows an investment of less than €25 per gCO_2/km in ICE technology will be sufficient for most carmakers to achieve their goals without requiring extremely high EV shares. But there will also be impacts on margins of selling more EVs and lower powered and lower CO_2 engines. Incurring penalties is bad business and will seriously undermine a company's reputation.

5.2 How carmakers can meet the 2020/21 targets

To close the gap all companies must now urgently implement their compliance plans which will comprise a mixture of:

1. Increasing sales of battery and plug-in hybrid electric vehicles. This is the most future-proof strategy beyond 2020. The number of models will triple by 2021 and production volumes will also rise significantly. By adopting more attractive pricing; and effective sales and marketing strategies focused on selling these vehicles, the gap to targets can quickly be closed. The Volkswagen Group, Renault-Nissan, Volvo, BMW Group and (to a certain degree) Daimler are all pursuing this strategy to a significant extent.
2. Making additional investments in new technology to lower the CO_2 emissions of conventional vehicles. This could include: engine upgrades, better tyres or mild and/or full hybrid systems.
3. Pricing, sales and marketing strategies to encourage customers to buy smaller and less powerful engines. This can save a few g/km but will have implications for profit margins.
4. Withdrawing some high emitting models from sale - for companies at risk of missing targets.

T&E's assessment of compliance options (Section 4) takes into account both a further (undesirable) increases in sales of SUVs[7] and (desirable) decline in diesel shares.[8] It shows that most companies will achieve the 2020 target because only 95% of cars count (the 5% of the highest emission models are omitted) and through using a significant fraction of their 7.5 gCO_2/km super-credit allowance to meet their goals. Figure 17 & Figure 18 summarise the compliance plans companies are most likely to use for 2020 and 2021 respectively, assuming they are able to sell the planned EV production.

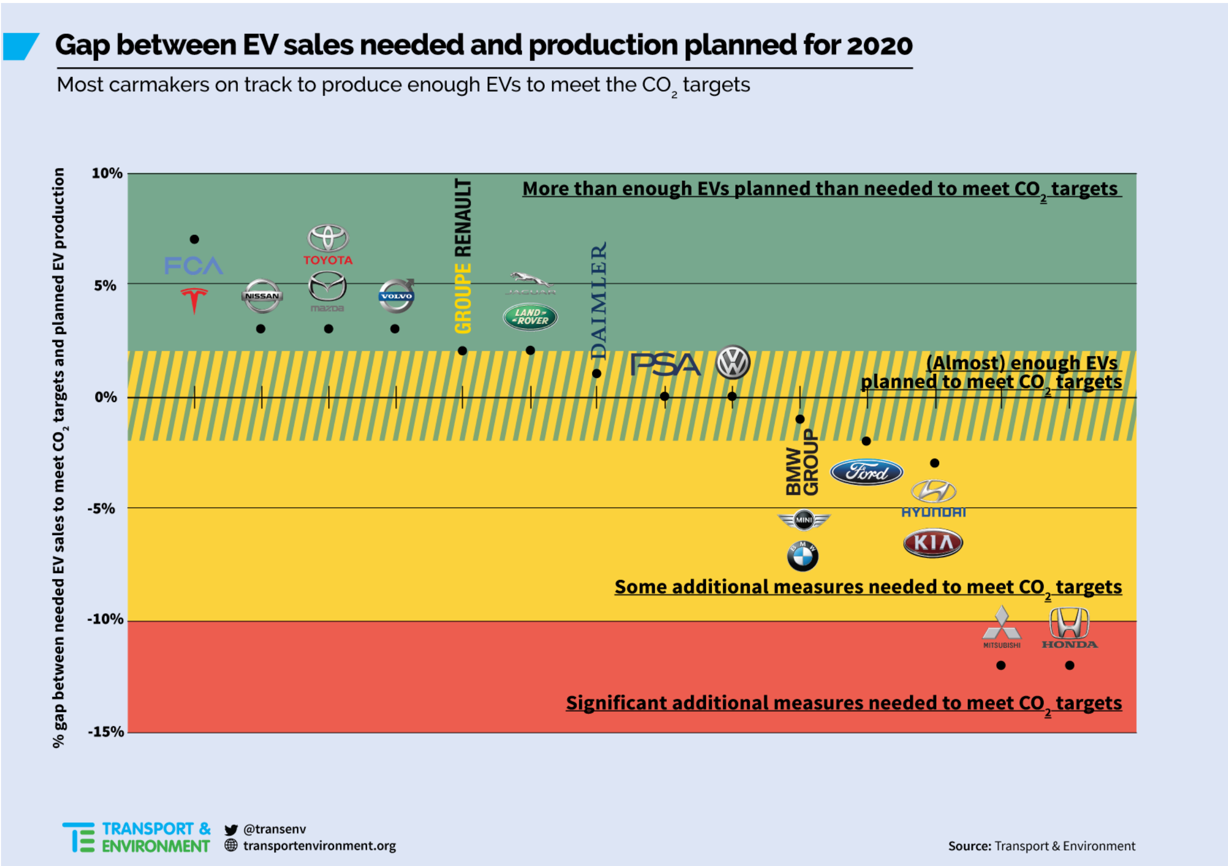


Figure 17 - NB: Companies in green/yellow area have required sales within 1% of planned production and are therefore within a margin of uncertainty: they could therefore follow either Plan 1 or Plan 2

[7] Sales of SUVs in 2021 are forecast to be about 39% of the EU market - More details in Annex 1

[8] Diesel market share in 2021 is estimated to be about 29% of the EU market - More details in Annex 1

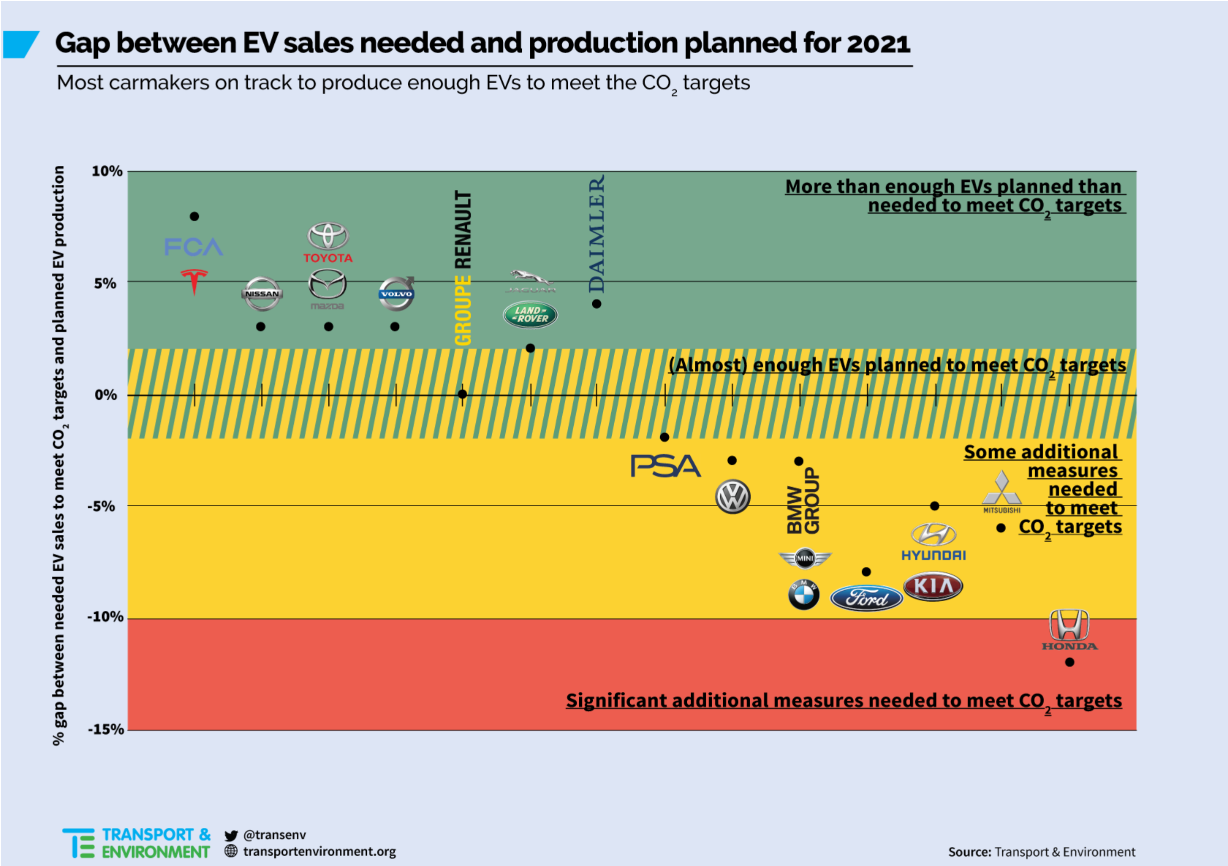


Figure 18 - NB: Companies in green/yellow area have required sales within 1% of planned production and are therefore within a margin of uncertainty: they could therefore follow either Plan 1 or Plan 2

There is a degree of uncertainty in assessing how many EVs carmakers need to sell for different compliance plans. There is also uncertainty in how many EVs carmakers can manufacture, particularly where these are imported into Europe. Forecasts for carmakers like Hyundai-Kia and Honda that also intend to launch full-hybrids in large numbers are particularly uncertain. Nevertheless, it is possible to indicate which carmakers will comply on a High, Central or Low EV scenario and which are at the margins of each compliance plan (green/yellow section in the table above). By increasing EV production, companies would shift into a higher compliance plan - this may be possible for some. Of course, if any carmaker could move quickly, additional EV production would enable them to comply. While more OEMs are behind the required EV production in 2021 (notably BMW Group, Volkswagen Group and Hyundai-Kia) compared to 2020, there is more flexibility and time to adjust and increase production needed by then (especially for those that use flexible platforms like BMW's or can export from domestic markets outside Europe like Hyundai-Kia).

Toyota is the clear leader in the race to meet targets, and through its hybrid strategy will have no difficulty achieving its 2020/21 targets. Toyota launched the first hybrid over 20 years ago - a technology that has served the company well but will be increasingly overtaken by battery solutions in the 2020's.

Honda is set to launch both hybrid and electric models but has the most challenging target to meet. No company is likely to require to withdraw high emitting models from sale in order to meet targets - although some may claim this is a reason.

5.3 Are the expected EV sales realistic?

Based upon the compliance plans the analysis indicates companies will need to follow and the production planned to date, the overall EV sales in 2020 are estimated to be around 5% (3-7% range), made up of half ZEVs. Sales of EVs in 2021 will be around 10% (7-12% range), made up of half ZEVs. The overall level of EV sales EU-wide is significantly higher than the 2% sales in 2018 that has recently risen to 2.9% in June 2019.

However, most companies plan significant number of new EV model launches that will [triple the number of models] available in 2021. Care must be taken in interpretation of production data as EU production will not precisely correlate with sales. The majority of EU EV production will be for EU sales but a fraction could be exported. In addition, some companies will import EVs from outside the EU to sell, and the analysis assumes a portion of this comes to the EU. This is important for non-EU companies (e.g. Ford, Hyundai-Kia, Toyota and Honda).

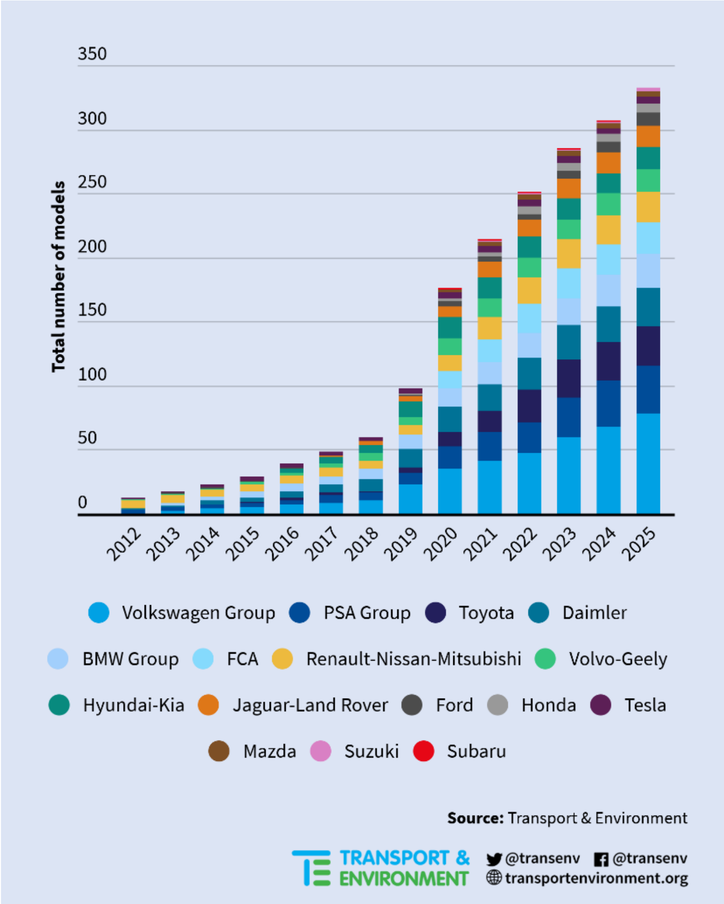


Figure 19 - Planned growth in EV models

Assuming planned production is delivered on time, this raises the key question - can all these new EVs be sold? There are several reasons for optimism:

1. Surveys of prospective buyers indicate an immediate untapped market of at least 10%. For example a 2018 survey in 5 countries found 5-12% of citizens across the countries said it is “very likely” the next car they buy will be electric. A much larger 40% of citizens said it was “likely”.
2. Most Governments have implemented tax breaks and grants reducing the higher upfront costs and around half of EU cars are sold to businesses. Such company car fleets can be electrified relatively fast thanks to their focus on total cost of ownership, availability of parking and hence charging and the tax incentives most EU governments have to green company car fleets.
3. There is a large amount of new charging infrastructure being installed. EU-wide there are now 175 thousand public recharging points - 1 for every 10 vehicles, and installations are growing quickly at around 50 thousand new installations a year.
4. Sales in Norway now count towards the target - with around 50% EV sales this will help meet the goals.
5. To date sales and marketing efforts have been minimal, but these are now increasing along with training and incentives for dealers.

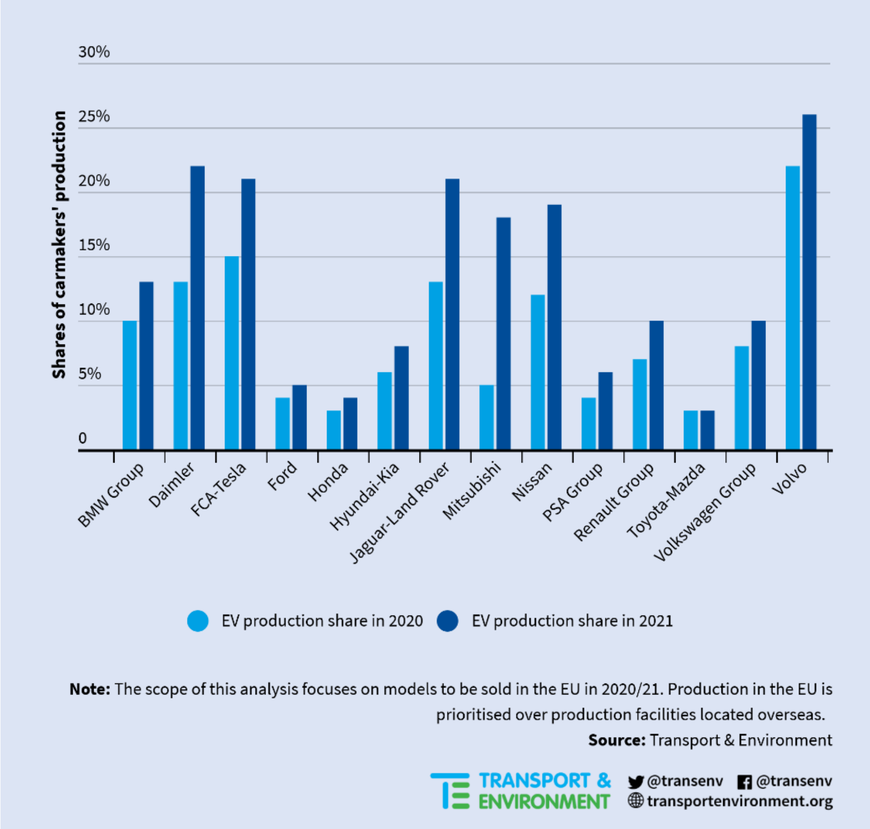


Figure 20 - Planned EV production for 2020 and 2021

Some companies will also seek to stock their car sharing fleets with electric cars; others will encourage staff to take EVs as company cars as a means to ensure the necessary sales are achieved. Volkswagen's WeShare EV sharing scheme in Berlin, BMW and Daimler's ShareNow or the recent comments by Kia on how it plans to make its company fleet electrified are some of the notable examples. Importantly, Daimler and the Volkswagen Group will offer their small city cars only as ZEV options: i.e. all Smart models from 2020 and Seat Mii, Škoda Citigo and Volkswagen up! from today already, this effect being already taken into account in T&E's model.[9] In order to give some additional perspective, in 2018, Smart represented about 10% of Daimler's EU registrations, while Volkswagen Group's city cars represented 4% of their 2018 European sales. These segments will help to contribute to the EVs that both groups need to sell to meet their respective CO_2 targets. In summary, achieving the required EV sales and therefore targets is a realistic prospect despite the current wide gap to be bridged.

5.4 Beyond 2021

This report has focused on compliance with 2020/21 CO_2 targets, but these only represent a stepping stone to more ambitious reductions for 2025 of 15% below the 2021 target and 37.5% by 2030. It is clear the principal compliance route to achieve these targets will be to sell increasing numbers of EVs, and for 2030 specifically ZEVs. For companies that have been slow to develop EVs, or manufacture these in significant numbers, this presents a major challenge. Notably: FCA (unless it continues to buy Tesla credits), PSA Group[10] and Ford will all struggle to comply with 2025/30 targets without a sizable share of EVs. The Toyota hybrid strategy has been remarkably effective to deliver its 2020/21 targets - but Toyota now sells over 50% hybrids and its strategy is to increase EV sales to meet 2025/30 goals. For 2030, it will not be able to comply only with hybrids, which are not a future-proof technology. By 2035 at the latest, only zero emission vehicles must be sold to achieve net zero emissions by 2050. Decarbonisation will be one of the key challenges of the twenty first century. Carmakers that can respond to this challenge will be the ones that succeed in business.

---

[9] Further explanations on the methodology of the model can be found in Annex 1

[10] Production data shows PSA plan a significant increase in production but to date are a laggard

5.5 Policy recommendations

The car CO_2 regulation has a checkered history but the current regulation, whilst imperfect, has established a sufficiently high target and penalty to ensure that it delivers a sizable reduction in new car emissions. T&E expects the 95 gCO_2/km NEDC target to be met overall by 2021, although emissions on the road will be much higher, around 132 gCO_2/km. It is essential to retain fair competition that any company incurring penalties is required to pay these. The regulation does not allow for any discretion and any attempt to revise the regulation would have severe competitive repercussions and would cast into doubt the credibility of one of the EU's key environmental regulations. ***The new European Commission should enforce the regulation as intended and not introduce any last minute weakening under pressure from Member States***.

Immediately, ***the European Commission and Member State testing services and type-approval authorities must ensure there is no manipulation of test results through an extensive process of conformity checking***. Companies must not be permitted to achieve targets through illegally lowering test results and there must be strong penalties for any companies doing so. The type of defeat devices used to detect testing of NOx emissions in the lab (which led to the Dieselgate scandal) can easily be used for CO_2 tests also. The European Commission's services should be independently verifying both the NEDC and WLTP declared values, and re-testing (and adjusting if necessary) road load coefficients to avoid cheating. In short, regulators must be much more vigilant than they have been over the last 20 years.

Targets for 2025 and 2030 have recently been agreed and will be measured on the new WLTP test procedure. Again, the design is imperfect but the inclusion of the mechanism to ensure similar emissions reductions are delivered on the road rather than just in the lab test is a key development. ***The European Commission must finalise the proposed approach to real-world checks and ensure this is implemented effectively and information made public***. The European Commission should also start using its new testing powers and independently check cars' CO_2 emissions on the road. ***The real-world mechanism should be made mandatory as part of the planned review in 2023. To be in line with the 2050 net zero pathway and clean up the air in cities, the European Commission should at the same time (2023) propose an EU-wide phase-out of internal combustion engined cars by 2035 at the latest.***

Moving forward, it is clear that national governments have a key role in lowering and ultimately decarbonising the cars on its roads. Several have already proposed a target for an end date for ICE sales or when only ZEVs can be sold. However, the European Commission recently warned Denmark such a policy is contrary to single market rules. Whilst countries could simply raise taxes on ICE vehicles to largely achieve the same objective, the European Commission should aide Member States' climate policies and support their choices how to achieve net zero emissions. At a national level, ***governments should assist in the shift to zero and low emissions vehicles by reforming systems of car taxation***. A recent T&E paper highlights the key opportunities and best practice including the French system of registration taxes that applies a discount for low and zero emissions cars paid for by a higher tax on high emitting vehicles (bonus-malus). The report also highlights the considerable potential of more widely and strongly linking company car taxation to the CO_2 emissions of the vehicle.

Making high mileage fleets such as taxis and corporate fleets zero emission as soon as possible (as some countries already doing) will accelerate their uptake and make these available in second hand markets much sooner. Incentives specifically to encourage the sale of zero emission cars including support for installing charging infrastructure will also accelerate the shift to these cars.

5.5 Final thoughts

The 2020/21 targets were agreed a decade ago and were relaxed in 2014 (through introducing a phase in and additional credits for selling EVs) so companies have had ample lead-time. The costs of non-compliance are also much higher. The analysis presented in this report shows that although the targets are challenging, they can still be met. Investors will therefore ask difficult questions why any company incurring penalties has been unable to plan to meet the target agreed a decade ago, and whether it has the funds, technology and skills to produce vehicles that will meet the increasingly demanding environmental standards in the future and a net zero world.

Claims by carmakers that the rise in diesel sales is the cause of rising emissions are found to be a gross distortion of the facts - it is the rise in SUVs that have been the main driver of rising emissions. The explosion in SUV sales is being driven by carmakers marketing and model launches whilst the decline in diesel stems from carmakers own irresponsible abuse of NOx emissions legislation. Unquestionably, most carmakers are far behind where they would wish to be and are now rushing to launch the lower carbon models and specifically EVs they will need to sell to meet their goals. By delaying progress to the last moment the costs will be higher than had they planned better.

It seems that the constant industry request for long lead-time before regulations are implemented is simply a strategy for delay. This regulation required the car industry to lower emissions by about 55g/km in 11 years. 4 months before sales begin to count towards the target, the industry are only half-way to the target! If the companies do incur penalties, they will only have their own bad decisions and woeful planning to blame and the penalties will be a necessary reminder they have environmental responsibilities that cannot be ignored.

Annexes

Annex 1 - Methodology of the model

This annex provides an overview of the methodology T&E developed to obtain the EV shares described in Section 4. The model is based on three main pillars in order to calculate the needed EV shares to meet 2020/21 CO_2 targets: the estimated CO_2 improvement from conventional ICE powertrains, the projected diesel and SUV market shares and the expected EV strategies. The Figure A1 shows a mapping of the model in complement of the explanations below. In Figure A1, the dashed boxes correspond to the input parameters that are changed between the different scenarios described in Section 4.

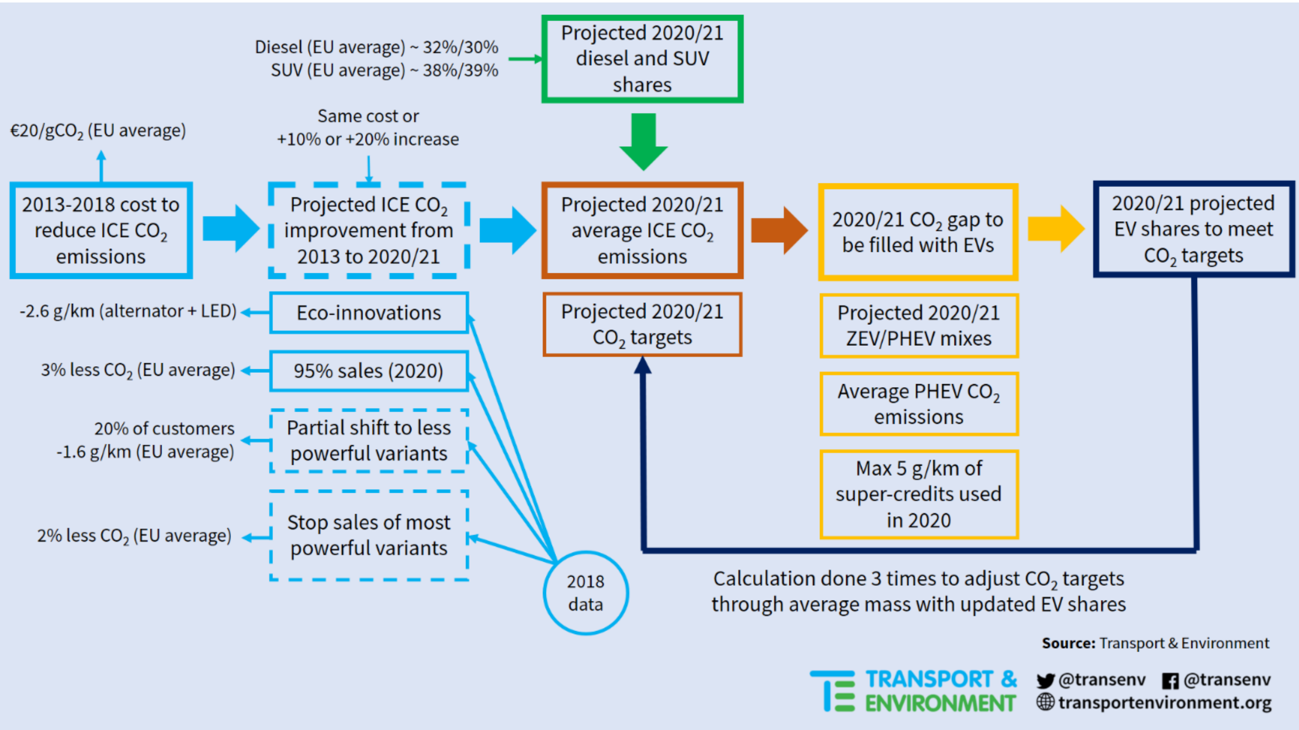


Figure A1 - Mapping of T&E's model

Overall assumptions:

T&E's model aims to determine the needed EV shares for each pool in order to strictly meet its own 2020/21 CO_2 target. Alternative fuels such as natural gas, LPG and E85 are not included as sales are marginal. Besides, it is assumed that the 2018 registrations for each pool remains constant in 2020 and 2021. T&E's analysis aims to be representative of the 2020/21 offer in terms of ICE models (based on carmakers' public announcements and IHS Markit's database): e.g. Opel stopping the production of the Adam, Cascada and Karl models without any remplacement, Ford dropping the sales of the Ka+ in Europe, Volkswagen Group's decision to offer their small city cars (Seat Mii, Škoda Citigo and Volkswagen up!) only as ZEVs from this year, similar decision with Daimler about the Smart brand from 2020, etc. T&E's model also includes carmakers' announcements linked to the partial or total stoppage of diesel sales, e.g. Mitsubishi, Nissan or Toyota. How carmakers are pooled in the model is described in the table x below. To a very large extent this relies on public information from the European Commission, either on the existing pools or the ones intended to be created.

CO_2 pool	Brand(s) included	Comment
BMW Group	BMW Mini Rolls-Royce	Same pool since 2016
Daimler	Mercedes-Benz Smart	Same pool since 2016
FCA-Tesla	Alfa Romeo Fiat Jeep Lancia Tesla	Applied for 2019 Statement from FCA's CEO this pooling agreement will continue in 2020
Ford	Ford	Same pool since 2016
Hyundai-Kia	Hyundai Kia	Currently declared as two seperate brands
Honda	Honda	Same pool since 2016
Jaguar-Land Rover	Jaguar Land Rover	Same pool since 2016
Mitsubishi	Mitsubishi	Same pool since 2016
Nissan	Nissan	Same pool since 2016
PSA Group	Citroën DS Opel Peugeot Vauxhall	Same pool as 2018
Renault Group	Alpine Dacia Lada Renault	Same pool since 2016 Addition of Alpine in 2018
Toyota-Mazda	Lexus Mazda Toyota	Same pool as 2018 Applied to continue in 2019
Volkswagen Group	Audi Bugatti MAN Porsche Seat Škoda Volkswagen	Same pool since 2016
Volvo	Volvo	Same pool since 2016

Source: Transport & Environment

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A1 - Pools of carmakers considered in T&E's model

Estimated CO_2 improvement from conventional ICE powertrains:

How much CO_2 improvement we can expect from conventional ICE powertrains relies on the 2020 cost curves that were developed by Ricardo and the JRC for the European Commission for the 2017 impact assessment of the post-2020 cars and vans CO_2 regulation proposal. These cost curves give an absolute cost in euros as a function of a reduction of WLTP CO_2 emissions in percentage, i.e. relatively to a 2013 baseline, without taking into account eco-innovations. These curves include four main segment categories for two fuel types (diesel, petrol with full hybrid technologies included for both). This is why T&E's baseline is also 2013 by using EEA's 2013 final database, complemented in order to add the segment information (coming from IHS Markit's database used for T&E's latest EV report. The conversion from NEDC CO_2 information to WLTP CO_2 values in order to use the Commission's 2020 cost curves is done by using JRC's WLTP uplift factors researched for the 2017 impact assessment as well. In the case where sales of a given carmaker on a specific segment started after 2013 then 2018 average CO_2 emissions are used in the analysis.

In addition, in order to understand what cost to use as an input, T&E looks at the CO_2 improvement between the 2013 baseline and the 2018 dataset, the latest one published by the EEA, with a breakdown per pool of carmakers, segment and fuel type and converts it into costs through the same 2020 cost curves. The EU average is found to be about €20/gCO_2 (with the 2018 sales mix). In order to estimate the average CO_2 emissions from ICE powertrains in 2020/21, the chosen assumption in the "Business as Usual" scenario is to keep the 2013-2018 costs per pool, segment and fuel type. If, for a given segment and fuel type, no CO_2 improvement or a too little one (i.e. below the minimum CO_2 savings prescribed for the specific cost curve) is noticed then the average cost for this specific pool applies. For the Plan 1, an increase of 10% is applied to these costs. Plans 2 and 3 apply a cost increase of 20%.

It is assumed that all new cars in 2020/21 are fitted with efficient alternators and LED lights, which bring an average CO_2 saving of 2.6 g/km (according the EEA 2018 database) through the eco-innovation scheme, regardless of the scenario. This assumption is taken on the basis that these are the two main technologies that carmakers have chosen so far (4 out of 5 cars fitted with eco-innovation in 2018), as they do not require to redesign the vehicles and replace a needed and existing component.

In order to assess the impact of counting only 95% of registrations in 2020 on the average CO_2 emissions for compliance purposes, the simulation is made for each pool based on 2018 data and assumed to remain unchanged. This results with a 3% reduction of CO_2 on average.

The partial shift to less powerful variants for Plans 2 and 3 is also based on EEA's 2018 database. For each pool and fuel type, the difference of the sales-weighted average CO_2 emissions from the two most sold engines is calculated between the 2018 levels of sales and the shift of 20% of registrations from the higher CO_2 emitting engine to the lower CO_2 emitting engine. The EU average of this effect is a reduction of about 1.6 g/km.

For Plan 3, stopping selling high CO_2 emitting models is also considered. This step is also based on 2018 data and looks at the EU-wide average CO_2 reductions for each segment, regardless of the fuel type. The value applied for each pool is then weighted based on the 2020/21 projected segment mixes that is described below.

Projected diesel and SUV market shares:

Section 3 describes the decline in diesel sales and the rise of SUV shares over the last 5 years. These trends are expected to continue towards 2020/21 and T&E's model aims to take this into account.

IHS Markit projects that 40% of EU sales in 2022 would be SUVs[11] so 2020/21 expected SUV shares are assumed to be a linear projection between 2018 levels and IHS's 2022 projection, i.e. 38% in 2020 and 39% the following year. Then, for each pool, the 2018 distribution of SUV sales is increased by a common EU-wide factor. For other segments, the 2018 distribution of sales is decreased by a common EU-wide factor in order to keep the total sales constant.

LMC Automotive projects that the EU-wide average diesel share would be about 32% in 2020 and 30% in 2021 in their base scenario.[12] The breakdown to the pool and segment level is then done in a similar way as for SUVs. For carmakers who sold full hybrid petrol cars in 2018 (i.e. Ford, Hyundai-Kia and Toyota-Lexus), an increase of registrations of such powertrains is taken into account for 2020/21. It is then assumed that the remaining sales for each pool and segment are made with non-hybrid petrol engines.

The estimated ICE CO_2 improvement is then combined with the projected diesel and SUV shares in order to have the 2020/21 average CO_2 emissions for each pool with conventional powertrains.
To calculate the 2020/21 CO_2 targets for each pool, it is assumed that the 2018 average mass for each pool, segment and fuel type remains constant. These values are then weighted-averaged by using the projected 2020/21 segment mixes for each pool. The difference between these two pieces of information gives the CO_2 gap to be filled with EVs in order to meet the target.

Expected EV strategies:

Each carmaker has its own strategy regarding EVs and the chosen mix between ZEVs and PHEVs has a strong influence on the total number of needed EVs to meet the target. T&E relies on IHS Markit's production database to get this information for each pool. Only models to be sold in Europe are considered (e.g. the F-Series pick-up truck from Ford is disregarded) and production of these models are prioritised over the overseas production. This filter gives the projected volume of production for ZEVs and PHEVs for 2020/21 but only the ratio between these two technologies is used in the model.

[11] IHS Markit, SUV-B segment to drive crossover growth in Europe, January 2018
[12] LMC Automotive, Powertrain - Long-term trends, The path towards Euro 7 event, May 2019

Regarding PHEVs, 2018 data is used as a basis to estimate the average CO_2 emissions from all PHEV models. This is completed by T&E's intelligence compiling the latest available public announcements from carmakers about new PHEV models coming to the market or new NEDC CO_2 values from existing models with the shift to WLTP regulation. These CO_2 figures are then averaged for each pool with the 2018 registrations figures of these specific considered models, regardless of the fuel type.

Regarding the use of super-credits, T&E understands that the regulation gives carmakers the flexibility to choose when and how much of super-credits they can use for the 2020-2022 period. In order to simplify the model, it is assumed that carmakers would use a maximum amount of 5 g/km of super-credits in 2020 and the remaining super-credits in 2021.

The combination of all these pieces of information allows T&E to calculate the needed EV shares to meet the CO_2 target for each pool. This calculation is made 3 additional times in an iteration process in order to adjust the average mass for each pool as, on average, EVs are heavier than models with conventional ICE powertrains. An EU-wide estimation is made based on 2018 data comparing both ZEV and PHEVs with the ICE equivalent for each carmaker. The same EU-wide ZEV and PHEV factor is used for all pools.

Annex 2 - Trends per Member State (2013-2018)

Avg. CO2 em. (g/km)	2013	2014	2015	2016	2017	2018
	131.5	128.5	123.6	120.4	120.7	123.0
	123.9	121.2	117.8	115.8	115.8	119.3
	140.7	135.3	130.2	125.5	126.1	126.9
	138.6	129.5	125.5	123.4	122.1	123.2
	134.4	131.6	126.2	121.1	124.0	125.6
	135.8	132.3	128.2	126.7	127.0	129.4
	112.3	110.1	106.1	106.0	107.1	109.5
	146.8	140.8	137.1	133.8	132.7	132.5
	122.1	118.5	115.2	114.3	115.0	118.0
	131.5	127.3	122.9	120.0	118.1	116.6
	117.2	114.2	111.0	109.8	110.3	112.1
	128.1	124.4	121.1	119.9	120.9	124.5
	111.7	108.1	106.3	106.3	108.8	111.1
	-	114.8	112.8	111.5	113.1	115.7
	134.2	132.9	129.6	125.9	125.6	129.0
	120.7	117.1	114.1	112.0	111.6	113.0
	120.9	118.0	115.2	113.2	113.2	115.5
	139.7	135.8	130.0	126.2	127.3	128.9
	133.1	129.7	127.3	125.8	126.6	131.0
	146.8	140.3	137.1	128.8	128.7	128.9
	118.1	114.8	113.1	111.7	111.0	105.9
	109.2	107.3	101.2	105.9	108.3	105.5
	137.7	132.9	129.2	125.8	127.6	127.7
	112.0	108.8	105.6	104.7	104.7	106.1
	132.1	128.2	125.0	122.0	120.6	121.4
	133.0	130.8	126.1	122.9	122.1	122.0
	125.3	121.2	119.2	119.0	119.6	121.0
	134.8	131.6	127.5	124.8	126.1	127.7
	126.7	123.4	119.5	118.1	118.5	120.4

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A2 - Average CO_2 emissions (g/km) of new registered cars by Member State from 2013 to 2018

Average SUV shares	2013	2014	2015	2016	2017	2018
	23%	23%	25%	28%	30%	37%
	18%	22%	24%	28%	32%	39%
	31%	30%	34%	36%	38%	42%
	31%	39%	42%	47%	52%	58%
	18%	19%	20%	17%	24%	29%
	17%	19%	20%	23%	26%	30%
	6%	10%	12%	14%	20%	26%
	35%	38%	37%	38%	40%	43%
	20%	22%	24%	29%	34%	39%
	18%	19%	20%	23%	28%	33%
	20%	24%	27%	28%	32%	37%
	18%	21%	25%	29%	33%	39%
	8%	12%	15%	19%	24%	28%
	-	15%	17%	22%	24%	32%
	22%	24%	29%	32%	39%	42%
	19%	23%	25%	31%	33%	42%
	18%	21%	25%	27%	31%	39%
	31%	33%	32%	35%	36%	37%
	23%	25%	27%	31%	35%	41%
	40%	43%	43%	39%	41%	44%
	17%	23%	27%	29%	32%	32%
	11%	15%	17%	21%	25%	30%
	22%	22%	24%	26%	28%	33%
	12%	14%	17%	19%	22%	29%
	22%	23%	25%	27%	29%	34%
	16%	22%	24%	26%	32%	36%
	16%	20%	23%	25%	28%	34%
	23%	24%	26%	28%	33%	37%
	18%	21%	23%	26%	30%	36%

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A3 - Average SUV shares per Member State from 2013 to 2018

CO2 increase from an average SUV	2013	2014	2015	2016	2017	2018
	23%	23%	23%	19%	17%	15%
	24%	21%	21%	19%	16%	14%
	31%	26%	21%	21%	19%	16%
	22%	14%	15%	14%	12%	11%
	25%	23%	22%	14%	18%	15%
	25%	23%	22%	20%	18%	15%
	21%	9%	12%	16%	11%	10%
	21%	19%	17%	17%	15%	11%
	18%	19%	18%	16%	15%	14%
	21%	17%	17%	15%	13%	12%
	18%	15%	15%	15%	14%	12%
	26%	21%	19%	17%	15%	16%
	34%	24%	19%	17%	15%	15%
	-	18%	19%	15%	13%	12%
	20%	19%	16%	13%	10%	12%
	20%	15%	15%	11%	10%	11%
	27%	22%	18%	15%	14%	14%
	27%	25%	24%	21%	17%	13%
	29%	25%	24%	23%	19%	17%
	26%	22%	24%	19%	15%	15%
	16%	7%	9%	11%	9%	16%
	34%	28%	27%	21%	17%	14%
	21%	21%	21%	19%	16%	17%
	16%	12%	11%	11%	9%	9%
	29%	27%	25%	21%	22%	18%
	22%	21%	19%	16%	14%	12%
	18%	15%	14%	13%	12%	11%
	25%	24%	22%	21%	19%	17%
	24%	20%	18%	17%	15%	14%

Note: The data represents for each Member State and each year the average increase of CO_2 emissions from registered SUVs (from B to E segment) compared with equivalent "conventional" cars (i.e. hatchbacks, sedans and station wagons) from the same segment range (i.e. B to E).

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A4 - CO_2 increase from an average SUV per Member State from 2013 to 2018

Average diesel shares	2013	2014	2015	2016	2017	2018
	57%	57%	58%	57%	50%	41%
	65%	62%	60%	52%	46%	36%
	53%	53%	53%	49%	43%	37%
	17%	39%	42%	43%	41%	39%
	43%	42%	44%	42%	40%	31%
	47%	47%	48%	45%	38%	32%
	34%	32%	31%	36%	35%	33%
	37%	36%	33%	27%	25%	25%
	66%	66%	63%	58%	50%	38%
	36%	38%	35%	32%	29%	22%
	68%	64%	59%	54%	49%	41%
	50%	50%	49%	48%	42%	32%
	58%	64%	63%	55%	44%	35%
	-	65%	63%	60%	55%	44%
	46%	45%	42%	36%	31%	23%
	73%	74%	72%	70%	65%	54%
	55%	55%	56%	58%	56%	53%
	58%	52%	49%	41%	35%	24%
	74%	72%	71%	65%	54%	47%
	54%	52%	47%	40%	40%	36%
	29%	37%	39%	36%	34%	29%
	26%	28%	30%	19%	17%	12%
	36%	34%	34%	30%	34%	26%
	73%	71%	69%	65%	61%	54%
	55%	57%	55%	51%	51%	40%
	60%	59%	58%	52%	48%	37%
	55%	56%	50%	50%	44%	32%
	48%	46%	45%	42%	38%	31%
	53%	53%	52%	50%	45%	37%

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A5 - Average diesel shares per Member State from 2013 to 2018

Average EV shares	2013	2014	2015	2016	2017	2018
	0.2%	0.6%	0.9%	1.5%	2.0%	2.7%
	0.2%	0.4%	0.8%	1.7%	2.7%	2.5%
	0.0%	0.0%	0.0%	0.4%	0.8%	1.1%
	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%
	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%
	0.3%	0.4%	0.7%	0.8%	1.6%	2.2%
	0.2%	0.6%	1.4%	0.8%	0.6%	2.1%
	0.6%	1.6%	0.2%	0.2%	0.2%	0.5%
	0.1%	0.1%	0.2%	0.3%	0.6%	0.8%
	0.2%	0.4%	0.6%	1.2%	2.6%	4.8%
	0.5%	0.6%	1.1%	1.3%	1.7%	2.0%
	0.1%	0.6%	1.1%	1.5%	2.0%	2.5%
	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%
	-	0.1%	0.3%	0.2%	0.1%	0.2%
	0.0%	0.1%	0.2%	0.5%	1.0%	1.5%
	0.1%	0.3%	0.5%	0.5%	0.7%	1.6%
	0.1%	0.1%	0.1%	0.2%	0.2%	0.5%
	0.0%	0.1%	0.3%	0.4%	0.3%	0.6%
	0.4%	0.8%	0.2%	0.7%	2.1%	2.1%
	0.0%	1.5%	0.2%	0.2%	0.3%	0.6%
	0.1%	0.3%	0.0%	0.2%	0.3%	3.3%
	3.2%	4.1%	9.5%	5.8%	2.3%	6.8%
	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%
	0.2%	0.2%	0.7%	0.9%	2.0%	3.7%
	0.0%	0.0%	0.1%	0.2%	0.3%	0.7%
	0.6%	1.6%	2.5%	3.6%	5.5%	8.4%
	0.0%	0.1%	0.2%	0.3%	0.7%	1.1%
	0.0%	0.1%	0.1%	0.2%	0.4%	0.5%
	0.3%	0.6%	1.0%	1.1%	1.4%	2.1%

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A6 - Average EV (i.e. ZEVs + PHEVs) shares per Member State from 2013 to 2018

Annex 3 - Trends per car manufacturer (2013-2018)

Avg. CO2 emissions (g/km)	2013	2014	2015	2016	2017	2018
BMW Group	134.6	131.7	126.6	123.0	121.8	127.5
Daimler	136.8	131.6	125.0	125.2	127.0	133.0
FCA	122.2	121.2	121.4	119.3	119.1	124.5
Ford	121.6	121.4	118.1	120.0	120.8	121.0
Honda	137.7	133.8	131.3	126.9	127.2	126.6
Hyundai	130.1	130.0	127.2	124.5	122.5	123.7
Jaguar-Land Rover	181.6	178.4	164.1	149.9	151.6	155.1
Kia	129.9	130.9	128.0	124.8	120.5	120.6
Mazda	134.1	128.1	126.1	126.7	130.8	134.6
Mitsubishi	123.9	114.6	110.0	118.1	117.6	121.4
Nissan	130.4	114.6	114.6	116.2	116.6	114.1
PSA Group	121.9	117.9	113.1	110.4	111.9	114.0
Renault Group	114.6	113.5	110.9	108.7	109.6	112.4
Toyota-Lexus	116.4	112.8	108.3	105.4	103.0	102.1
Volkswagen Group	128.6	125.6	121.3	120.1	121.5	121.9
Volvo	130.8	126.5	121.8	121.2	124.4	132.2
EU-28	126.7	123.4	119.5	118.1	118.5	120.4

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A7 - Average CO_2 emissions (g/km) of new registered cars by car manufacturer from 2013 to 2018

Average SUV shares		2013	2014	2015	2016	2017	2018
BMW Group		26%	27%	22%	25%	26%	32%
Daimler		10%	13%	15%	20%	23%	25%
FCA		9%	9%	21%	22%	21%	30%
Ford		7%	10%	14%	18%	22%	27%
Honda		34%	37%	42%	48%	46%	40%
Hyundai		24%	26%	29%	35%	34%	40%
Jaguar-Land Rover		80%	80%	78%	80%	84%	88%
Kia		29%	33%	36%	40%	43%	50%
Mazda		34%	31%	38%	46%	49%	54%
Mitsubishi		70%	73%	74%	73%	71%	74%
Nissan		76%	68%	68%	72%	73%	73%
PSA Group		13%	19%	21%	21%	27%	37%
Renault Group		17%	25%	29%	33%	31%	32%
Toyota-Lexus		11%	12%	12%	16%	29%	31%
Volkswagen Group		12%	12%	13%	14%	20%	27%
Volvo		21%	28%	34%	40%	43%	48%
EU-28		18%	21%	23%	26%	30%	36%

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A8 - Average SUV shares per car manufacturer from 2013 to 2018

CO2 increase from an average SUV		2013	2014	2015	2016	2017	2018
BMW Group		15%	14%	16%	12%	9%	6%
Daimler		35%	23%	20%	19%	18%	20%
FCA		46%	48%	23%	15%	15%	14%
Ford		34%	29%	19%	18%	19%	23%
Honda		31%	19%	12%	7%	10%	14%
Hyundai		24%	25%	25%	21%	22%	19%
Jaguar-Land Rover		23%	22%	28%	25%	24%	19%
Kia		26%	26%	28%	24%	16%	8%
Mazda		10%	14%	15%	16%	18%	19%
Mitsubishi		38%	44%	45%	50%	48%	51%
Nissan		18%	5%	7%	7%	15%	19%
PSA Group		8%	8%	7%	7%	6%	4%
Renault Group		15%	10%	9%	9%	12%	11%
Toyota-Lexus		45%	42%	44%	30%	14%	10%
Volkswagen Group		30%	32%	31%	27%	20%	16%
Volvo		38%	31%	22%	18%	17%	19%
EU-28		24%	20%	18%	17%	15%	14%

Note: The data represents for each car manufacturer and each year the average increase of CO_2 emissions from registered SUVs (from B to E segment) compared with equivalent "conventional" cars (i.e. hatchbacks, sedans and station wagons) from the same segment range (i.e. B to E).

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A9 - CO_2 increase from an average SUV per car manufacturer from 2013 to 2018

Average diesel shares		2013	2014	2015	2016	2017	2018
BMW Group		74%	73%	70%	66%	60%	49%
Daimler		66%	67%	65%	63%	61%	55%
FCA		32%	34%	38%	38%	40%	35%
Ford		45%	44%	45%	46%	45%	35%
Honda		32%	41%	42%	38%	26%	18%
Hyundai		38%	37%	42%	42%	33%	19%
Jaguar-Land Rover		93%	92%	92%	93%	91%	81%
Kia		44%	47%	46%	48%	40%	28%
Mazda		43%	42%	38%	32%	26%	19%
Mitsubishi		39%	35%	30%	30%	23%	13%
Nissan		49%	51%	49%	50%	48%	40%
PSA Group		54%	54%	50%	45%	41%	35%
Renault Group		59%	56%	56%	53%	48%	40%
Toyota-Lexus		23%	25%	21%	15%	8%	5%
Volkswagen Group		56%	57%	56%	53%	47%	38%
Volvo		87%	90%	89%	83%	79%	64%
EU-28		53%	53%	52%	50%	45%	37%

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A10 - Average diesel shares per car manufacturer from 2013 to 2018

Average EV shares		2013	2014	2015	2016	2017	2018
BMW Group		0.2%	1.0%	1.4%	3.1%	5.0%	6.7%
Daimler		0.5%	0.5%	1.2%	1.6%	2.7%	2.9%
FCA		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ford		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Honda		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hyundai		0.0%	0.0%	0.0%	0.1%	1.1%	2.6%
Jaguar-Land Rover		0.0%	0.0%	0.0%	0.0%	0.0%	4.3%
Kia		0.0%	0.0%	1.3%	0.9%	2.0%	3.8%
Mazda		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mitsubishi		0.8%	19.7%	23.2%	15.1%	13.5%	15.3%
Nissan		1.5%	2.3%	2.4%	2.8%	2.6%	6.1%
PSA Group		0.2%	0.1%	0.1%	0.1%	0.1%	0.2%
Renault Group		0.8%	0.8%	1.2%	1.3%	1.7%	2.2%
Toyota-Lexus		0.9%	0.2%	0.1%	0.0%	0.3%	0.4%
Volkswagen Group		0.0%	0.2%	1.1%	0.9%	1.1%	1.4%
Volvo		3.7%	2.1%	3.2%	4.3%	3.8%	6.4%
EU-28		0.4%	0.6%	1.0%	1.1%	1.4%	2.1%

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A11 - Average EV (i.e. ZEVs + PHEVs) shares per car manufacturer from 2013 to 2018

Annex 4 - 2018 gap to close to 2020/21 CO_2 targets per pool

CO_2 pool	2018 performance	2018 performance with 95% sales	2020/2021 target with 2018 average mass	Gap to 2020 target	Gap to 2021 target
Toyota-Mazda	110.5	107.5	94.0	13.4	16.5
Nissan	114.1	111.2	94.6	16.6	19.5
Renault Group	112.4	110.2	91.7	18.5	20.7
Jaguar-Land Rover	155.1	150.1	130.6	19.5	24.5
Mitsubishi	121.4	116.3	96.4	19.9	25.0
PSA Group	114.0	111.7	91.3	20.4	22.7
BMW Group	127.5	123.8	102.0	21.8	25.5
Volvo	132.2	129.8	107.7	22.1	24.6
Volkswagen Group	121.9	118.3	96.1	22.2	25.8
Ford	122.3	118.4	96.0	22.4	26.3
Daimler	133.0	128.1	102.4	25.7	30.5
FCA-Tesla	122.1	119.0	92.3	26.7	29.8
Hyundai-Kia	122.2	119.4	93.5	25.9	28.7
Honda	126.6	123.9	94.3	29.6	32.3
EU average	**120.5**	**116.9**	**95.2**	**21.6**	**25.3**

Source: Transport & Environment from EEA data

TRANSPORT & ENVIRONMENT @transenv @transenv transportenvironment.org

Table A12