CLEARING THE AIR AROUND DIESEL

FUTURE LOOK ON DIESEL: APPROACH & SOLUTIONS

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ARVAL
BNP PARIBAS GROUP

We care about cars.
We care about you.

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EXECUTIVE SUMMARY

Diesel currently accounts for more than half of the passenger car and light commercial vehicle registrations in Europe. In true fleets segment, this share is even two-thirds.

Consumer reaction following the recent defeat device scandals together with concerns over vehicle access restrictions in certain large cities has led to growing uncertainties around the future of diesel across the European markets. This was the trigger for Arval to issue this white paper on diesel.

As an independent multi-brand lessor of vehicle fleets across Europe, Arval scrutinises all trends and expert views around vehicle technologies and usage, as well as offering its advice and support to clients and drivers to make the best choices when selecting a new vehicle. With these recent questions and challenges expressed around Internal combustion engines in general and diesel in particular, but also bearing in mind that alternative energies are becoming more and more available, Arval has fully reviewed its Total Cost of Ownership (TCO) calculation. The Arval methodology already included a fuel cost element and applicable taxes, but will also integrate the possibility to take specific driver segments into account in terms of total mileage driven, as well as driving patterns and locations; this should enable clients to make a better balanced selection across all vehicle types.

Air quality and Diesel viability

The primary environmental focus over the last 20 years has been on Greenhouse Gas (GHG) emissions and more specifically Carbon Dioxide (CO_2). As a result, an uneven playing field in favour of diesel has been introduced in Europe. The CO_2 based approach, which is directly linked to fuel consumption efficiency, coupled with rising fuel prices overall, has significantly increased the market share of diesel vehicles across Europe, at the expense of petrol cars.

Recently there has been growing awareness around the discrepancies between the out of date New European Drive Cycle (NEDC) laboratory test values for fuel consumption, CO_2 as well as air pollutants (particularly Nitrogen Oxides – NOx) and those achieved in real life tests measured on the road. The VW emissions scandal in 2015 and the understanding that urban air pollution, in reality, has not improved as much as expected, has accelerated the debate around the environmental impact of different fuel types in particular diesel cars.

As a result, some governments have announced (such as France and the UK) to end the sale of new conventional petrol and diesel cars and vans by 2040, as well as the introduction of Low Emissions Zones (LEZs) in a number of major cities. It should be noted that, in our view, LEZs will not ban all diesel vehicles overnight, but will initially impact older generations first, significantly limiting any negative effects on fleets in the coming years, since fleet vehicles are generally younger.

The NEDC has been replaced with the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) and the Real Drive Emission Test Procedure (RDE). The emission figures produced from these new tests should better reflect real driving conditions. A transition period until 1st January 2019 should allow OEMs (Original Equipment Manufacturers) and local governments enough time to adapt, whilst the resulting values should in the eyes of the European commission not directly lead to a higher tax impact, even though it is already known today that variances of 20% (but up to 80%) will exist compared to today's values.

In order to achieve the 2021 average CO_2 reduction targets, all the mainstream OEMs have been adapting their strategies by introducing new technologies, in combination with and sometimes the substitution of diesel and even petrol. Many of these strategies, however, still imply the use of diesel vehicles, some of which will be upgraded and include hybrid versions, the main reason being that such strategies require high investment and time to be executed. It is very likely that diesel will not just disappear overnight since alternative fuel investment costs are high and take a considerable amount of time to execute. Stakeholders should take this into account.

Even though the reputation of diesel has suffered in the eyes of the public in recent months, it is important to understand that much of the recent diesel shift in corporate fleets has moved into petrol, especially in the smaller vehicle segments. This is mainly due to the removal of a more expensive diesel offering from the OEMs in these segments and a partial move into electrified vehicles (essentially hybrid and plug-in hybrid) due to the fiscal incentives.

Evidence suggests that the general public across Europe is shifting away from diesel, so over time, offer and demand will need to be reconciled in the second hand markets as well. There is likely to be pressure on diesel Residual Values (RVs) going forward to the benefit of alternatives available in the short term, mainly petrol, hybrids (including plug-in hybrids) and, to a lesser extent, full electric vehicles.

Arval mission and approach

Arval's mission is to help clients to make the right choice in this fast-evolving regulatory and vehicle manufacturing environment, giving expert advice on technological choices that make sense in the short, medium and long term. Company car policies will need to be adapted as early as next year. Our Total Cost of Ownership model has been reviewed to take into account these new dynamics.

In our discussions around TCO, we will encourage our clients to include their internal driver segments in the criteria to define and sometimes impose the right choices for, not only the driver, but also for the company and the environment as a whole. Arval's consulting teams can accompany our clients in their fleet profiling exercise and help them to build or rebuild their car and mobility policies to tackle these new challenges.

As public awareness has grown regarding Climate Change as well as the broader environmental impact of vehicles, Arval believes that Corporate Social Responsibility should be on the agenda of its clients more than ever before. Not only do we intend to inform our clients as soon as the information from the new tests is readily available, we will propose to clients to use our new services, such as Arval Active Link, to better measure, monitor and influence driver behaviour, in order to minimise the true environmental impact of their fleets.

As you will see in this white paper, diesel vehicles will still remain a very valid option in many situations, because of their fuel efficiency and the OEMs taking decisive action to minimise their impact on the environment. However, in progressively more and more cases, hybrid, plug-in hybrid and even full electric vehicles will become better alternatives, besides petrol.

This is a changing political environment and the content in this paper is based on the information available to date and any potential implications and options are not limited to what is detailed in this document.

1 | REGULATORY FRAMEWORK

1.1 | Emissions overview

Petrol and diesel combustion engines produce a variety of different emissions, the main ones being CO_2, Nitrogen Oxides (NOx), particulates, un-burnt hydrocarbons (HC) and Sulphur compounds, with differing environmental implications. A glossary of terms can be found in Appendix 1.

This white paper primarily focuses on NOx (an air pollutant which has a negative impact on health) and CO_2 (this is not an air pollutant but a primary greenhouse gas that contributes towards global warming and climate change).

For a number of years, governments have incentivised the step by step decrease in CO_2 emissions, contributing to a worldwide attempt to limit global warming. Fiscal regulation and related actions by the OEMs and lessors including Arval, have adopted car policies in favour of diesel cars, making the direct link to fuel efficiency and CO_2 to control costs and at the same time contribute to Corporate Social Responsibility policies. NOx was not really on the agenda, until it became clear that tests were structurally abused and resulting CO_2 and NOx values were not at all in line with real expectations on the road.

The transport sector is the largest contributor to NOx emissions, accounting for 46% of total emissions in the EU in 2013 and a significantly higher contribution of roadside NOx concentrations.

The increasingly stringent Euro emission standards have led to significant drops over the last two decades in exhaust emissions of PM and other pollutants such as HC and CO. According to tests of on-road emissions conducted by the International Council on Clean Transportation (ICCT), Euro 6 vehicles emit at least 40% less NOx than Euro 3 vehicles.

Whilst this is clearly a significant improvement; overall NOx emissions and in particular NO_2 have not been reduced as much as expected. This is partly because the growth in the number of vehicles, and in particular the growth in the volume of diesel vehicles, has been higher than expected. It is now also recognised that the 'real world' emissions of NOx, particularly from cars and vans, generally exceed the laboratory test based emission standards and according to real-road tests performed by the ICCT only 10% outperform the Euro 6-limit.

1.2 | Emissions regulation

All countries in Europe are currently required to report air quality data on an annual basis under specific European Directives: The Council Directive on ambient air quality and cleaner air for Europe (2008/50/EC) and The Fourth Daughter Directive (2004/107/EC) under the Air Quality Framework Directive (1996/62/EC).

Vehicle manufacturing air pollution regulations

Vehicle emission standards (known as the Euro emission standards) have been in place since 1992 and regulate the emissions of PM, NOx, CO_2 and HC; they are adopted as part of the EU framework for the type approval of cars, vans, trucks, buses and coaches.

Because the combustion temperature in a diesel engine is higher than a petrol one, the emissions of NOx are higher. The emissions of NOx standards are progressively tightening and converging between Petrol and Diesel.

INTRODUCTION DATES			NOx (g/km)	
Euro Standard	New type approvals	All new registrations	Petrol	Diesel
Euro 1	1st July 1992	31st December 1992	0.92[1]	0.97[1]
Euro 2	1st January 1996	1st January 1997	0.5[1]	0.9[1]
Euro 3	1st January 2000	1st January 2001	0.15	0.5
Euro 4	1st January 2005	1st January 2006	0.08	0.25
Euro 5	1st September 2009	1st January 2011	0.06	0.18
Euro 6	1st September 2014	1st September 2015	0.06	0.08

1: Expressed as HC + NOx

1 | REGULATORY FRAMEWORK

Vehicle manufacturing CO_2 regulations

Within the EU, road transport is responsible for about 20% of all CO_2 emissions with passenger cars and vans accounting for about 15% of the total CO_2 emissions.

The EU regulation (443/2009) sets mandatory CO_2 emission reduction targets at the OEM level for the actual sales of new cars and Light Commercial Vehicles (LCVs – goods vehicles weighing up to 3.5 tonnes) registered by the manufacturer.

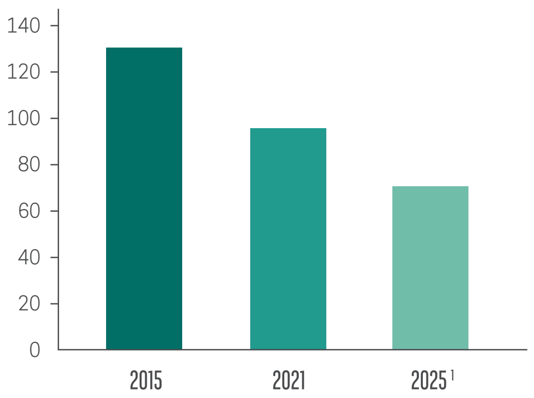
The manufacturer's emission limits for CO_2 are set according to the mass of vehicle, using a limit value curve meaning:

- Heavier cars are allowed higher emissions than lighter cars (which is potentially favourable to diesel engines).
- Only the fleet average is regulated, OEMs are still able to make vehicles with emissions above the curve, as long as these are balanced by vehicles below the curve.

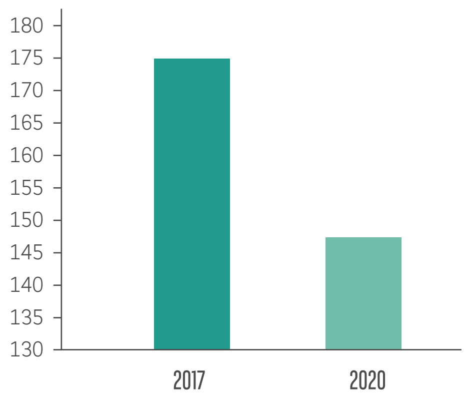
If the average CO_2 emissions of an OEM's fleet exceed its limit value, the OEM has to pay an excess emissions premium for each car registered. From 2019, the cost will be €95 from the first gram of exceedance onwards.

There are also additional incentives for the OEMs to produce vehicles with extremely low emissions (below 50g/km).

Targets in g/km for cars



Targets in g/km for LCVs



1: A longer term target has not been agreed yet but this has been suggested as the next target / date

1.3 | New Test Procedure (WLTP-RDE)

As of September 2017, the European Commission has introduced two new vehicle emission testing procedures to replace the previous New European Drive Cycle (NEDC), a laboratory test, used to measure fuel consumption and CO_2 emissions from passenger cars, as well as their pollutant emissions.

World Harmonised Light vehicle Test Procedure (WLTP)

The WLTP is a globally harmonized test procedure developed within the United Nations Economic Commission for Europe (UNECE) with the support of the European Commission.

Unlike the NEDC, which was based on a theoretical driving profile, the WLTP cycle was developed using real driving data gathered from around the world and should, therefore, provide fuel consumption and CO_2 emission values that are more representative of real world conditions.

The new test is mandatory for all new type approvals from September 1st 2017 and for all new cars from September 2018. During the transition period, up until the end of 2018, consumer information will only show NEDC values (derived from the WLTP values). From January 2019 consumer information will only show WLTP values to avoid confusion.

It is anticipated that National governments will adjust vehicle taxation and financial incentives to WLTP values, respecting the principle that WLTP should not have a negative impact on consumers.

From the table shown below, it is clear that the variation and total duration of the WLTP test will be much greater than the NEDC in order to provide a more realistic picture of actual consumption and emission. The new test also takes the impact of the various options that come with the vehicle.

1 | REGULATORY FRAMEWORK

Preliminary tests with existing vehicles indicate huge variations on average + 20% versus previously announced CO_2 values. So it will be a real challenge in the coming months to anticipate how local governments will deal with CO_2 based taxation. Main differences with the previous test are listed in the chart below.

Another aspect of the WLTP relates to the vehicle manufacturing CO_2 regulations (outlined in Section 1) of 95g/km by 2021. This value of 95g/km was determined on the basis of the NEDC. In the short term, they will therefore be dealing with a WLTP value and an NEDC value derived from it.

	NEDC	WLTP
Test cycle	Single test cycle	Dynamic cycle more representative of real driving
Cycle time	20 minutes	30 minutes
Cycle distance	11 kilometres	23.25 kilometres
Driving phases	2 phases, 66% urban and 34% non-urban driving	4 more dynamic phases, 52% urban and 48% non-urban
Average speed	34 kilometres per hour	46.5 kilometres per hour
Maximum speed	120 kilometres per hour	131 kilometres per hour
Influence of optional equipment	Not considered	Additional features are taken into account
Gear shifts	Vehicles have fixed gear shift points	Different gear shift points for each vehicle
Test temperatures	Measurements at 20-30°C	Measurements at 23°C, CO_2 values corrected to 14°C

Real Driving Emission (RDE)

In the Real Driving Emissions (RDE) procedure, pollutant emissions – which include NOx and particulate emissions – are measured by portable emission measuring systems (PEMS) that are attached to the car while driving in real conditions on the road. This means that the car will be driven outside and on a real road according to random variations of parameters such as acceleration, deceleration, ambient temperature, and payloads.

These tests can easily be corroborated by independent organisations (University research, NGO) that will be able to publish their results.

The RDE procedure does not replace but complements the laboratory test, which has also been improved to better reflect real driving conditions, in particular to provide more realistic CO_2 emission and fuel consumption figures.

1.4 | Low Emission Zones

LEZs are areas where the operation of older, more polluting, vehicles are regulated and are often considered to be the most effective measure that towns and cities can take to reduce the emissions of fine particles, NO_2 and (indirectly O3) and so improve air quality.

LEZ access criteria are based on the Euro Emission Standards, although the requirements may differ by fuel type (petrol vs diesel) to take into account the differences in PM and NO_2 emissions. Whilst LEZ requirements are not consistent across the EU or even within individual countries they typically take one of two formats:

- A ban on higher emission vehicles; vehicles below a certain Euro Standard are not permitted to enter the LEZ e.g. diesel commercial vehicles built before 1st January 2000 (essentially Euro 2) are not permitted to enter the Amsterdam LEZ.
- Charging schemes for higher emission vehicles; vehicles below a certain Euro Standard will be charged a fee or toll to enter the area whilst vehicles meeting the criteria can enter for free e.g. the London Ultra Low Emission Zone (scheduled for September 2020) will require all vehicles that do not meet the minimum criteria (Euro 4 for petrol vehicles and Euro 6 for diesel) to pay a daily charge.

One of the major inconsistencies across LEZs (both across Europe and within individual countries) is with regards to the types of vehicles that are impacted.

Despite all the hype around the introduction of LEZs and diesel vehicles being banned from city centres the current (and planned) access restrictions are generally very limited and will have minimal (if any) impact on fleet operators in the near future.

2 | MANUFACTURER STRATEGIES

Over recent months several European governments have announced their intention to stop the sale of new diesel and petrol vehicles over the next 8-25 years (U.K. 2040, France 2040, Germany 2030, Netherlands and Norway potentially by 2025). Whilst these announcements are clearly positive from an environmental/air quality perspective, they have given rise to concerns about the practicality of moving to an all-electric vehicle market in a relatively short space of time.

However, it's important to remember that many of these proposed bans such as the one announced by the U.K. will only apply to vehicles that do not have some form of electrical propulsion and as such traditional hybrids and plug-in hybrids (both of which use some form of petrol or diesel motor) in addition to pure electric vehicles will not be included within the ban.

The challenge for OEMs in reducing CO_2 and pollutants at the same time resides in the fact that they require conflicting measures: an attempt to decrease CO_2 causes an increase of pollutant emissions.

- **A car engine running at high temperature tends to emit less CO_2 but more NOx.**
- **A lower engine temperature will result in more CO_2 but less NOx.**

Each of the OEMs have specific challenges ahead of them, compared to where they are coming from today. It is clear that when addressing the combined challenge of having to bring down further CO_2 across their range of vehicles sold, as well as limiting NOx to an acceptable "true" level, they will be forced to invest in hybrid technology (traditional and plug-in), full electric vehicles and potentially both. This, however, requires significant investment and a total overhaul of their traditional business models for which some OEMs are better prepared than others.

Many manufacturers have recently announced their "strategies for electrification", some examples are detailed below. It is worth noting that developing a new model takes around three years, so any announcement made in 2017, if developments have not started before the announcement, will result in vehicles only being available from 2020 onwards:

- **BMW** expect that by 2025, electrified vehicles will account for 15-25% of sales. Most models will be available with several alternatives (traditional, hybrid, or electric), as BMW platform will allow multiple energy types. As BMW was an early adopter of EV technologies (i3 and i8 already on the road), new EV models will probably be rolled out from 2018 onwards.

- **Hyundai & Kia** plan to launch 26 models across three technologies; plug-in hybrid, pure electric and fuel cell by 2020. The success of the Ioniq which was launched across 3 different electric powertrains has demonstrated their commitment to EVs which will probably be followed up with new vehicles from 2018 onwards.

- **Jaguar Land Rover (JLR)** has committed that all new model launches from 2020 will include an electric motor (i.e. will therefore be a hybrid, plug-in hybrid or pure EV). The first EV will be launched in 2018 (I-Pace).

- **Mercedes** has announced a 10-billion-euro investment in electrification to ensure that by 2020 all new Smart models will be fully electric and after 2022 all Mercedes-Benz models will be offered with some sort of plug-in hybrid or full electric drivetrain. Launch of EV models will be from 2019 onwards.

- **Peugeot – Citroen (PSA)** will have 4 pure electric and 7 plug-in hybrid vehicles by 2021. Like BMW, most models will be available with several powertrains (traditional, hybrid, or electric). Nevertheless, PSA will probably not launch any new pure EVs before late 2019, having relaunched its EV developments quite late.

- **Renault – Nissan – Mitsubishi Alliance** is the EV leader in many countries with ZOE and LEAF, and is developing synergies in their full electric programs across all 3 brands.

- **Toyota** is the world leader in traditional hybrid technology; although it plans to continue to invest in this technology and also explore hydrogen solutions, developments in China will result in an increased focus on pure EVs.

- **Volkswagen Audi Group (VAG)** has announced that all 300 models in the VAG range (which includes SEAT and Skoda) will come with electrification by 2030. VAG has committed to 80 new electrified models by 2025, 30 of which will be Plug-in hybrids and 50 pure-electric. The first EV will not be launched before 2020 (ID).

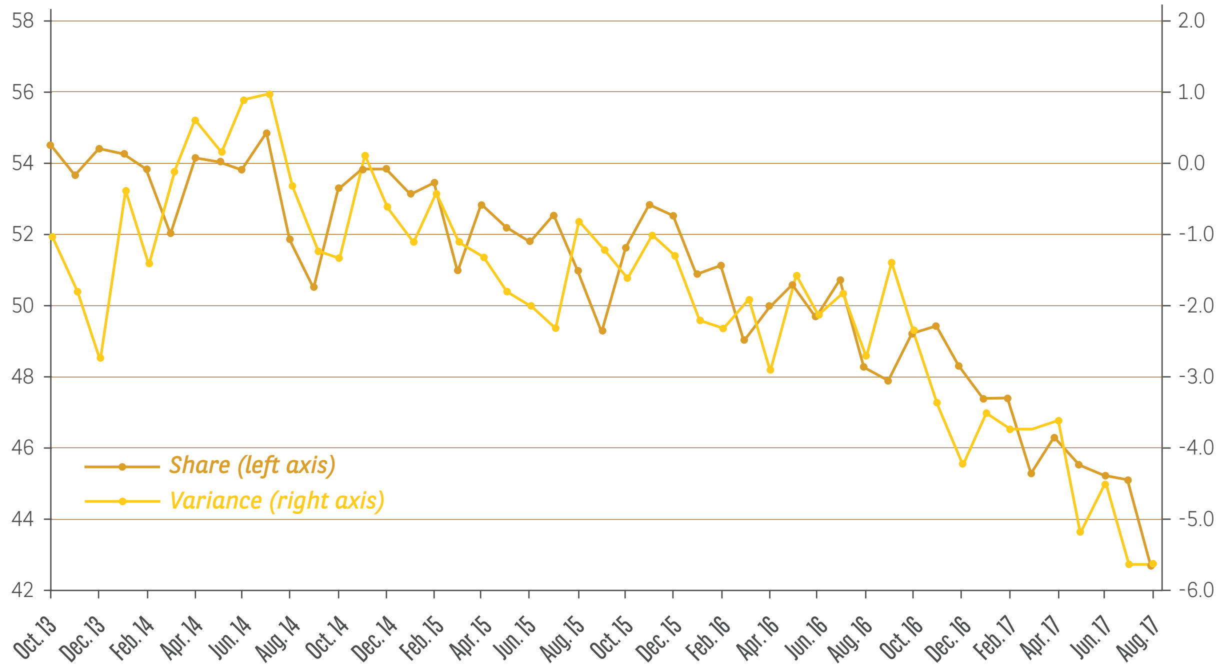
- **Volvo** has made a similar new model launch commitment as JLR but from 2019 instead. Pure EVs from Volvo will probably not be available before that date.

The majority of manufacturer announcements in this area all confirm plans that will see a larger range of plug-in and/or pure electric vehicles come to market within the next 3 to 5 years; a very much shorter timescale than that associated with the proposed banning of all new diesel and petrol vehicles by many countries. Consequently, we would suggest that these impending bans will only serve to maintain manufacturer focus on a target that most likely would have been achieved anyway.

Nevertheless, most OEMs have no diesel exit strategies available and will still use diesel as an important part of their powertrain strategy for the foreseeable future combined with offering alternatives.

3 | OFFER & DEMAND OF DIESEL

Western Europe Diesel Car Share & Monthly YoY Variance (%)



Diesel Share of New Car Sales (%)

	AUG-17	AUG-16	YOY	YTD AUG-17	YTD AUG-16	YOY
Austria	49.3	56.6	-7.3	50.8	57.5	-6.7
Belgium	48.0	53.8	-5.8	46.4	52.2	-5.8
Denmark	30.6	35.3	-4.7	35.5	35.7	-0.2
Finland	28.5	30.5	-2.0	31.6	33.1	-1.5
France	47.5	51.4	-3.9	47.9	53.0	-5.1
Germany	37.7	45.3	-7.6	40.9	46.8	-5.9
Greece	40.0	53.1	-13.1	41.5	52.1	10.6
Ireland	55.7	70.8	-15.1	65.1	69.8	-4.7
Italy	57.6	58.7	-1.1	56.6	56.5	0.1
Luxembourg*	55.0	63.1	-8.1	54.0	64.2	-10.2
Netherlands	18.3	1.5	-1.2	17.7	18.2	-0.5
Norway	22.4	28.4	-6.0	24.9	31.7	-6.8
Portugal*	62.0	66.7	-4.7	61.4	64.1	-2.7
Spain	48.6	57.4	-8.8	49.6	56.9	-7.3
Sweden	47.9	48.0	-0.1	51.3	53.1	-1.8
Switzerland	34.1	39.5	-5.4	37.1	39.5	-2.4
UK	39.6	47.3	-7.7	43.5	48.0	-4.5
WESTERN EUROPE	**42.7**	**48.3**	**-5.6**	**45.7**	**50.0**	**-4.4**

Western European Diesel Car Market – new vehicle registrations

Although diesel's market share in the EU-15 countries has been steadily declining year on year since hitting a peak of 56.1% in 2011, it has accelerated since the VW scandal down to 49.9% in 2016. It is fair to say that this decline is predominantly limited to the lower vehicle segments of private individuals' car registrations, which indicates that it is mainly a reputational rather than a pure economic (or TCO) based shift in demand.

LMC Automotive reports that, although subject to revision, the August 2017 diesel market share has dropped to its lowest level since 2003 and shows a 5.6% drop against the same period in 2016. The YTD figure, whilst not as sharp as the monthly figure still shows a 4.4% drop.

The diesel shift is more predominant for private individuals than corporate fleets.

The used car market shift is dependent on the duration of new car retention. The fact that this duration is significantly higher for private individuals than corporate fleets should lead to a smoother transition.

It is also worth noting that if the used car market diesel dynamics are not the same between urban and rural areas of a particular country or amongst countries in North West Europe and the other continental zones, the fluidity of the market is likely to mitigate the impacts.

The declining popularity of diesel vehicles is very likely to have an impact on residual sales values over time, subject to availability in the second hand market of valid alternatives to diesel (initially limited to petrol and to a lesser extent, hybrid vehicles). The 3/4 year projections made by the Arval experts on residual values is fairly consistent across the G7 countries, with diesel prices expected to decrease by approximately 2.5% on average with less impact as the vehicle segment increases.

Diesel is still the dominant fuel type in the fleet industry although recently this position has gradually started to erode. This is primarily due to less availability of diesel in the lower segments and a growing choice of hybrid and plug-in hybrid models, the majority of which are petrol, for which there is often a company car tax or fiscal advantage together with the improved cost effectiveness (to the driver and or the company) of some petrol models.

Plans by the UK and French governments to ban the sale of new petrol and diesel vehicles by 2040 together with the commitment by the mayors from 4 of the world's largest cities to ban diesel vehicles by 2025 coupled with coverage in the media around the air quality issues surrounding diesel, have understandably led to some concern around the continued viability of operating diesel cars within a company fleet.

4 | FUEL TYPE COMPARISON

This section looks to compare the relative merits of diesel and petrol and then to examine the separate implications of hybrids, plug-in hybrids, full electric vehicles and other alternative energies such as hydrogen and gas.

At this point, it is important to remember that the use of a dynamic Total Cost of Ownership (TCO) within a company car choice list structure (that incorporates a fuel cost element) by default ensures that the most cost-effective car is chosen irrespective of its powertrain technology. But in certain cases, the specific driver segments and related driver patterns and requirements, will progressively play a more important role in the vehicle allocation policies.

4.1 | Diesel vs Petrol

Diesel cars usually have a price premium (typically in the region of €1,000-€2,000 although it can be higher) which is generally not fully realised in the residual value.

- Diesel cars, therefore, often have a higher monthly lease cost against the comparable petrol model.

Diesel cars are generally more fuel efficient than the equivalent petrol cars.

- A lower fuel consumption reduces business fuel costs and personal fuel costs.
  This is particularly relevant for high mileage drivers.
- Diesel fuel costs less than petrol in most European countries.
  Coupled with a better fuel efficiency, the lower fuel cost for diesel cars usually offsets the higher lease costs for a lower TCO.
- In the countries where diesel is more expensive (Czech Republic, Switzerland and the UK) the cost benefit of the higher fuel efficiency is reduced and may not be sufficient to offset the higher lease cost for a lower TCO.
  If the fuel price differential increases then any cost benefit of the higher fuel efficiency significantly reduces.

Diesel cars produce higher real-life air quality emissions than petrol cars.

- Although the Euro 6 standard should mean that they are comparable, in real life conditions they are reported to be significantly worse than the standards allow.
- Although not an immediate / short term practical risk for company cars the future introduction of air quality related restrictions will eventually impact the wider fleet suitability of diesel.
- From a CSR perspective, there may be an increasing pressure over the next few years on organisations to focus on their air quality impact.
- It cannot be excluded that local governments, as the public opinion pressure may increase on reducing NOx emissions, will start defining fiscal rules based on NOx.

Petrol engine technology has also significantly improved in recent years with the growth of smaller capacity turbo engines.

- These retain the performance of traditional larger capacity engines but are more efficient and therefore have much lower CO_2 emissions than previous engines.
  The variance between the CO_2 figures of equivalent petrol and diesel models is often now only a few g/km (5-10g/km).
- They have lower list price values than equivalent diesel models and so are more comparable from an overall company car tax perspective.
- It is likely that local governments will gradually increases taxes on diesel and make sure that at the pump, the price of diesel will be the same or higher than petrol.

4.2 | Hybrid Electric Vehicles (HEV)

A traditional or conventional Hybrid vehicle combines an internal combustion engine (usually petrol) with a very small battery pack and electric motor. The battery pack cannot be charged from an external power source but uses a system of energy recovery. This technology has existed now for nearly 20 years, and as such is perhaps no longer viewed as new or alternative, but is now considered a mainstream powertrain.

There are essential two types of HEV:

- Toyota is the world's leader in Full HEV technology and has been offering a large range of hybrid choices for many years which have been accepted by the used car buying public.
- In the Toyota system, each of the power sources can drive the car separately or they can work together. At low speeds the engine is turned off and the car drives on electric power only, when more power is required or for maximum acceleration both work together. At higher speeds the car runs on the engine only.
- Many OEMs already have HEV models available which operate in a similar way as to the Toyota system.
- An alternative Mild HEV system is provided by Honda where the car is always powered by the engine with the motor only providing extra power when required.

The Toyota HEV system is particularly suited for low speed urban usage which requires numerous stop and starts and so reduces consumption and emissions. Drivers who routinely make longer journeys may not get the best fuel consumption out of the technology which could result in a higher TCO than expected.

A new generation mild hybrid system is currently being developed by a number of manufacturers. This technology uses a combined 12V and 48V system – 12Vs for the lighting and infotainment and the 48Vs for the more power hungry components. This new set-up should provide two-thirds the benefit of a full hybrid at a third of the cost and should increase fuel economy by 15%-20%.

4 | FUEL TYPE COMPARISON

4.3 | Plug-in Hybrid Electric Vehicles (PHEV)

A PHEV also combines both a battery pack and electric motor with an internal combustion engine. Like a full HEV, both the electric motor and the internal combustion engine can drive the wheels. The battery pack in a PHEV (typically 10-12kWh) is much larger than a HEV; however it is also much smaller than in a pure EV limiting the electric range (depending on make and model) to 30-50km.

- PHEVs generally have significantly lower official CO_2 emissions than the equivalent petrol or diesel models and therefore often have a company car tax advantage. To date, these low emission figures have been on the basis of the NEDC test procedure. It is not clear at this stage what the impact of the WLTP / RDE will have on the CO_2 figures of PHEVs in the future.
- The official MPG (miles per gallon) or consumption information (litre/km) can be misleading in terms of what might be achieved in reality:
  - The actual fuel consumption is likely to be significantly higher than the official figures. It is important to remember that there is a difference between the actual engine / fuel consumption and the overall consumption of the vehicle due to the additional electric miles where the engine is not used.
  - However, this is very much dependent on the charging discipline of the driver. Those who charge at every opportunity will achieve a better overall MPG than those who don't.
  - Drivers with an overall mileage profile that allows for a greater proportion of electric km versus the engine will be better suited to a PHEV. This implies lots of short journeys (rather than routinely driving long distances) in order to minimise the overall consumption.
- There is evidence that some drivers have chosen PHEVs purely for a fiscal or tax benefit without any consideration of their journey profile or their ability to regularly charge the battery:
  - The resulting MPG and CO_2 emissions have been significantly worse than the equivalent diesel or petrol car.
  - Fiscal benefits for PHEVs are already being reviewed (e.g. Belgium and the UK) to incentivise cars with larger battery capacities (and therefore greater electric range).
- The availability of PHEVs on a car fleet can be a positive contribution to a broader CSR policy on carbon and air pollution reduction, however if the driver doesn't recharge frequently enough, the fuel consumption is likely to be significantly higher than expected resulting in a negative impact on the environment and the TCO.

4.4 | Pure Electric Vehicles

A pure electric vehicle only uses a battery pack and electric motor producing zero tail pipe emissions. The battery pack (typically 25 – 40kWh) is much larger than in a PHEV and as a result they have a much greater electric range with 200 – 300km being increasingly common.

- The number of models available is still relatively limited although this is changing, improvements in the technology coupled with the fiscal or taxation incentives is facilitating the growth conditions of this market. Some key factors like the recharging time cycle, infrastructure development should also be considered.
- The original limited range (on one charge) of these vehicles has meant that they have been mainly targeted to date at urban or semi-urban use. However, the rapid improvements in battery technology and the resulting increase in range is gradually changing the potential optimum driver profile.

4.5 | Hydrogen Fuel Cell Vehicles (FCEV)

A hydrogen fuel cell electric vehicle is essentially an electric vehicle that uses hydrogen to charge a battery pack to power an electric motor. An FCEV has a hydrogen tank that can be refilled with pressurised hydrogen in minutes. When this hydrogen is passed through a 'fuel-cell stack', electricity is generated for the car's batteries and motor.

- **FCEVs have two primary advantages over other fuel types:**
  - Water vapour is the only tail pipe emission and so there are zero NOx and particulate matter emissions.
  - The range from a single tank of hydrogen is approximately 480km.
  - Refuelling the hydrogen tank takes approximately 3-5 minutes.
- **However, the primary disadvantages are:**
  - The technology is still extremely expensive
  - The current refuelling infrastructure is extremely limited
  - There are no fuel economy benefits as the fuel consumption / cost of hydrogen makes the cost per km comparable to an internal combustion engine
- Although the availability of FCEVs is extremely limited, fuel cell technology in vehicles is emerging in various manufacturers' research programs (principally Toyota, Hyundai and Honda).
- As with most emerging technologies, cost will reduce as interest and take up increases. We monitor the development of this market with interest over the coming years.

4.6 | Natural Gas Vehicles (NGV)

A Natural Gas Vehicle uses either compressed natural gas (CNG) or liquefied natural gas (LNG), however although both use natural gas, the technologies (and the resulting infrastructure requirements and costs) are significantly different.

- Despite 20 million of these vehicles being registered and driven across the globe (primarily in China, Iran, India and Pakistan), the NGV is not an emerging solution.
- **The fuel does have some strong advantages for passenger cars and LCVs:**
  - 25-30% reduction of CO_2 emissions
  - Almost zero tail pipe Particulate Matter and NOx emissions
  - Better fuel economy than diesel
- **However, the above are countered by some important disadvantages:**
  - The fuel tank requires a lot of space
  - The installation remains expensive
  - Natural gas is also more expensive than the previous liquid gas
  - Distribution network is very limited
- After considering these pros and cons it appears that users are not convinced by this solution, but real interest still exists in public fleets.

5 | DIESEL VIABILITY

Arval's position is to help clients analyse their fleets and needs, to provide advice on a factual basis and then recommend the best solution in terms of TCO.

This section aims to cover the most common questions being asked around the continued viability of diesel vehicles within a company fleet.

Should a company car policy be restricted to diesel only?

- In most cases, diesel is a valid choice for high mileage drivers and this will continue to be so for a number of years still, looking at a pure Total Cost of Ownership (TCO) perspective based on true expected duration, real consumption and especially mileage driven per annum.
- Arval believes that any car policy should be based on TCO which incorporates fuel efficiency and cost including taxes and then there is no real reason to maintain a restricted fuel policy i.e. diesel only. However, having different sorts of powertrain technologies for different driver segments, it makes it more difficult to internally reallocate vehicles.
- The company car tax benefits of diesel cars have eroded due to the price premium for diesel models (in the region of €1,000-€2,000) and the reduction in the CO_2 variance between petrol and diesel models. On this basis, it is not uncommon for petrol models to be cheaper for the driver than the equivalent diesel, so this should be carefully looked at.

Will company car tax for diesel cars increase?

- At least 20 countries in the EU apply some form of CO_2 based taxation on company cars which has been a key factor in the growth of diesel vehicles on company car fleets in the last 15 years. And even though the test methodologies will change, this should in principle still be in favour of diesel as opposed to petrol in the years to come.
- In many countries, there are already fiscal incentives for ultra-low emission vehicles (<76g/km) which are all currently electric (pure-electric or plug-in hybrid).
- It is impossible to predict whether individual taxation schemes will specifically penalise diesel cars in the future or even whether the incentives for ultra-low emission vehicles will increase.
- It is likely that the impact of the introduction of the WLTP will be assessed first before any steps are taken, so any fundamental changes are not really expected until early 2019. It is possible that any potential realignment of taxation schemes to incorporate WLTP figures in 2019 may be used as the opportunity to introduce measures to dis-incentivise diesel cars.

Will diesel cars be restricted or banned from city / town centres?

- It is likely that Low Emission Zones or access restrictions to city / town centres will gradually be introduced or tightened over the next few years.
- However, there is significant inconsistency across Europe with regards to the access criteria and vehicles impacted within the existing Low Emission Zones.
- Current entry criteria in most Low Emission Zones is quite low (typically Euro 2 or 3 for diesel vehicles) and any planned tightening of the criteria (moving towards Euro 6) is quite slow with 2025 being the focus point for many zones.
- From a fleet perspective, unless diesel cars are banned outright, which is not expected in the short to medium term, any additional access restrictions are unlikely to have any real impact.

Should a driver choose a diesel car or opt for an alternative?

That is a question that only the individual can answer and is a decision that must be made taking into account their individual tax situation, vehicle requirements (regarding their business and private needs), business and private journey profile and electrification / charging opportunities.

- From an air quality emissions perspective, diesel is clearly more polluting than petrol. However, Euro 6 engines are significantly cleaner than older engines (albeit still worse in real life driving than petrol).
- From a carbon emissions perspective, diesel engines are generally noticeably more fuel efficient than the equivalent petrol engine. The associated carbon emissions are therefore lower, which from a climate change perspective is extremely important.
- Lower CO_2 emissions usually mean that a diesel car has a lower company car tax liability.
  - Diesel cars may incur additional tax in the future which will need to be balanced against any fiscal incentives for ultra-low emission vehicles
  - Better fuel economy means lower fuel bills for private mileage even when taking in to account the higher fuel price for diesel
- The suitability of plug-in vehicles (whether pure-electric or plug-in hybrid) in terms of the access to charging facilities, electric range and typical journey profiles needs to be considered carefully.
- For someone who does relatively low annual mileage and the majority of their journeys are local / urban rather than on the motorway then perhaps the petrol or a plug-in vehicle option is more appropriate but this is a very personal decision.

APPENDIX | GLOSSARY

Benzene A chemical compound that is harmful to human health. As an air pollutant, benzene can be emitted from domestic and industrial combustion processes, and road vehicles. Its chemical formula is C6 H6.

Benzo [a] Pyrene One of a group of compounds called polycyclic aromatic hydrocarbons (PAHs) that can be air pollutants. The main sources of B[a]P in the UK are domestic coal and wood burning, fires, and industrial processes such as coke production.

1,3-Butadiene This is an organic compound emitted into the atmosphere mainly from fuel combustion e.g. petrol and diesel vehicles. 1,3-butadiene is also an important chemical in certain industrial processes, particularly the manufacture of synthetic rubber. 1,3-butadiene is known to cause cancer in humans.

Carbon Monoxide (CO) a pollutant gas found released in road vehicle exhausts. When breathed in, carbon monoxide affects the blood's ability to carry oxygen around the body.

Microgram per cubic metre (µg m-3) Unit often used to express concentration of a pollutant in air. 1 µg = 1 millionth of a gramme or 1 x 10-6 g.

Micrometre (µm) Unit of length often used for the size of particulate pollutants. 1 µm = 1 millionth of a metre (1 x 10-6 m) or one thousandth of a millimetre.

Milligram per cubic metre (mg m-3) Unit often used to express concentration of carbon monoxide in air. 1 mg = 1 thousandth of a gramme or 1 x 10-3 g.

Nickel (Ni) A toxic metallic element found in ambient air as a result of releases from oil and coal combustion, metal processes, manufacturing and other sources.

Nitric oxide (NO) One of the oxides of nitrogen formed in combustion processes. NO is not harmful to human health but combines with oxygen to form nitrogen dioxide.

Nitrogen Dioxide (NO_2) One of the oxides of nitrogen formed in combustion processes. At high concentrations NO_2 is an irritant to the airways. NO_2 can also make people more likely to catch respiratory infections (such as flu), and to react to allergens.

Nitrogen Oxides Compounds formed when nitrogen and oxygen combine. NOx, which comprises nitric oxide (NO) and nitrogen dioxide (NO_2), is emitted from combustion processes. Main sources include power generation, industrial combustion and road transport.

Ozone (O3) A pollutant gas which is not emitted directly from any source in significant quantities, but is produced by reactions between other pollutants in the presence of sunlight. (This is what is known as a 'secondary pollutant'.) Ozone concentrations are greatest in the summer. O3 can travel long distances and reach high concentrations far away from the original pollutant sources. Ozone is an irritant to the airways of the lungs, throat and eyes: it can also harm vegetation.

Particulate Matter (PM) Small airborne particles. PM may contain many different materials such as soot, wind-blown dust or secondary components, which are formed within the atmosphere as a result of chemical reactions. Some PM is natural and some is man-made. Particulate matter can be harmful to human health when inhaled, and research shows a range of health effects associated with PM. In general, the smaller the particle the deeper it can be inhaled into the lung.

PM10 Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 10 µm aerodynamic diameter, as defined in ISO 7708:1995, Clause 6. This size fraction is important in the context of human health, as these particles are small enough to be inhaled into the airways of the lung – described as the 'thoracic convention' in the above ISO standard. PM10 is often described as 'particles of less than 10 micrometres in diameter' though this is not strictly correct.

PM2.5 Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 2.5 µm aerodynamic diameter, as defined in ISO 7708:1995, Clause 7.1. This size fraction is important in the context of human health, as these particles are small enough to be inhaled very deep into the lung – described as the 'high risk respirable convention' in the above ISO standard. PM2.5 is often described as 'particles of less than 2.5 micrometres in diameter' though this is not strictly correct.

Polycyclic Aromatic Hydrocarbons (PAH) PAHs are a large group of chemical compounds that are toxic and carcinogenic. Once formed, they can remain in the environment for a long time, and can be passed up the food chain. The main sources are domestic coal and wood burning, outdoor fires, and some industrial processes. The pollutant benzo [a] pyrene is a PAH, and because it is one of the more toxic PAH compounds it is measured as a 'marker' for this group of pollutants.

Sulphur dioxide (SO2) An acid gas formed when fuels containing sulphur impurities are burned. SO2 irritates the airways of the lung.

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