FAST FORWARD
TO ELECTRIC VEHICLES

White Paper

ARVAL
BNP PARIBAS GROUP

For the many journeys in life

EXECUTIVE SUMMARY

In 2018, pure internal combustion engines[1] (ICE) still accounted for 95% of all passenger car registrations in Europe. Within the next 5 years this will drastically change, with electrified vehicles making up almost half of the market by 2025 and growing to more than 70% by 2030. **This shift away from petrol and diesel to electrified vehicles will be as drastic as the drop of diesel** in the last few years and there are very good reasons for explaining this change.

1 | Conventional internal combustion powertrain (pure petrol and diesel) with no electric or air drive. Stop/start systems (including micro-hybrids) are counted here.

EXECUTIVE SUMMARY

5 key factors that will accelerate the shift to electrified vehicles as of 2020

1 **European Regulation** is forcing car manufacturers to invest heavily in cleaner technology. These regulations have been reinforced in recent years and are to protect the public health as well as to combat climate change. By 2021, hefty fines may impact car manufacturers that do not comply with the carbon emission targets.

2 The cost of regulation pushes up the cost of ICE vehicles, whereas the reduction in battery costs and the increasing availability of **attractive battery electric vehicles (BEV) models is making electrification a better option**. As a result, the total number of plug-in hybrid, battery electric and to a lesser amount fuel cell vehicles is expected to increase from 100 models today to 214 in 2021 and 325 by 2025.

3 **Reputational issues** around diesel and more broadly around ICE vehicles will not fade away and as such, the demand for electrified vehicles is rising. Although significantly better than they were, ICE vehicles (particularly diesel) still emit harmful tail-pipe emissions and the public opinion around them is not expected to change. Low emission zones (LEZ), in towns and cities, will continue to be introduced with total bans on diesel or even all ICE vehicles. This is expected in selected city areas by 2025.

4 **Reducing Range Anxiety** as the significant growth in the charging infrastructure together with the fact that many new battery electric vehicles now have real-life ranges in excess of 300km, with some up to 500km. When combined with public charging facilities, car sharing and/or vehicle switching solutions, users can plan longer distances when needed.

5 **Fiscal measures** to stimulate electrified vehicle sales are available in 24 out of the 28 EU states. Although only 12 EU members offer bonus payments or premiums to buyers at acquisition most countries grant tax reductions or exemptions for electric cars. A full overview is on the European Automobile Manufacturer Association[2] (ACEA) website. In addition some countries, like Norway, provide incentives on vehicle usage which can include free tolls, free parking, free public charging and even access to bus lanes.

2 | https://www.acea.be/publications/article/overview-of-incentives-for-buying-electric-vehicles

EXECUTIVE SUMMARY

Fast forward from ICE to EV

The internal combustion engine will remain a key component of the energy mix for some time to come and not only because hybrid vehicles still require a combustion engine.

Car manufacturers will also need time to shift their production lines to full electric vehicles in a cost effective way, whilst continuing to upgrade the existing diesel and petrol engines to bridge this transition.

Through 2020, the shift towards full electric vehicles will continue to accelerate, with the latest diesel and, to a lesser extent, petrol vehicles continuing to be a suitable choice for fleet customers in quite a number of cases.

But make no mistake, the shift from ICE to EV vehicles has started and it is important not to be left behind.

Arval's mission and approach

Arval's mission is to help clients to make the right choice in this rapidly evolving vehicle manufacturing environment, giving expert advice on powertrain choices and the mobility solutions to take that make sense in the short, medium and long term.

Arval's consulting teams, through the **Arval SMaRT** (Sustainable Mobility and Responsibility Targets) approach, can support companies in their fleet and mobility profiling exercise and help them to build or develop their car and mobility policies to tackle these new challenges.

Considering Arval's and more broadly BNP Paribas' CSR ambitions, we want to be key contributors in the energy transition. This does not only mean that we continuously are investing and partnering to expand our services to promote full e-mobility and connected mobility, we have also committed to fully deploy the principles that come out of SMART to ourselves including the full review of our own car policies, a process that has been started from the moment we launched SMaRT during summer last year.

White Paper Motivation

Following the Arval "Clearing the Air around Diesel" white paper in November 2017, this new paper aims to provide an update to the changing automotive landscape. Along with an overview of the primary powertrains available going forward and the use cases in which to consider them individually, this paper includes the Arval's approach in selecting the optimal powertrain, 10 reasons to introduce battery electric vehicles (BEV) in your fleets and provides recommendations on how to successfully make this transition.

By publishing it, Arval recommends that whilst the latest Euro 6d diesel vehicles, together with petrol and other electrified options, will remain a valid option for many drivers, it is time that fleet operators prepare themselves for an accelerated shift towards BEVs over the next few years, particularly where there are strong corporate and personal tax incentives in place or upcoming.

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 | INTRODUCTION

95%
of car registrations in 2018 are **Internal Combustion Engine** (ICE) vehicles

10 yrs
for **electric vehicle** registration to **be equal to ICE** registration

4 x
more **electric vehicle** models available in **2021 vs 2018**

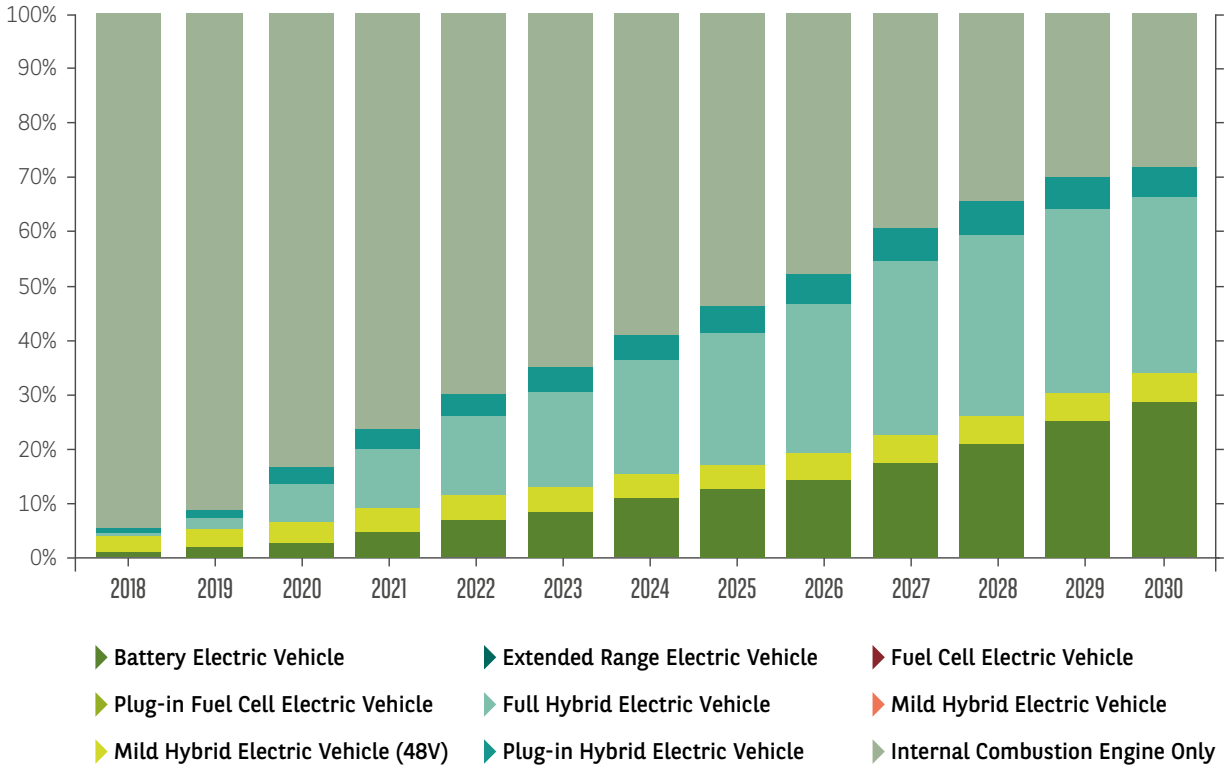
A rapidly evolving automotive landscape

In 2018, Internal Combustion Engine (ICE) vehicles accounted for 95% of all passenger car registrations. Within 5 years, this is expected to reduce to 55% and **within 10 years the proportion of pure ICE vehicles** (Petrol and Diesel)**, Hybrids** (Mild, Full and Plug-in) **and Electric Cars** (Battery, Extended and Fuel cell) **will almost be equal**.

As such, although the landscape is changing and primarily benefiting the Mild Hybrids and the Battery Electric Vehicles (BEV), the foreseeable future will consist of a broad mix of powertrains. A short description for each powertrain is provided in Section 2.

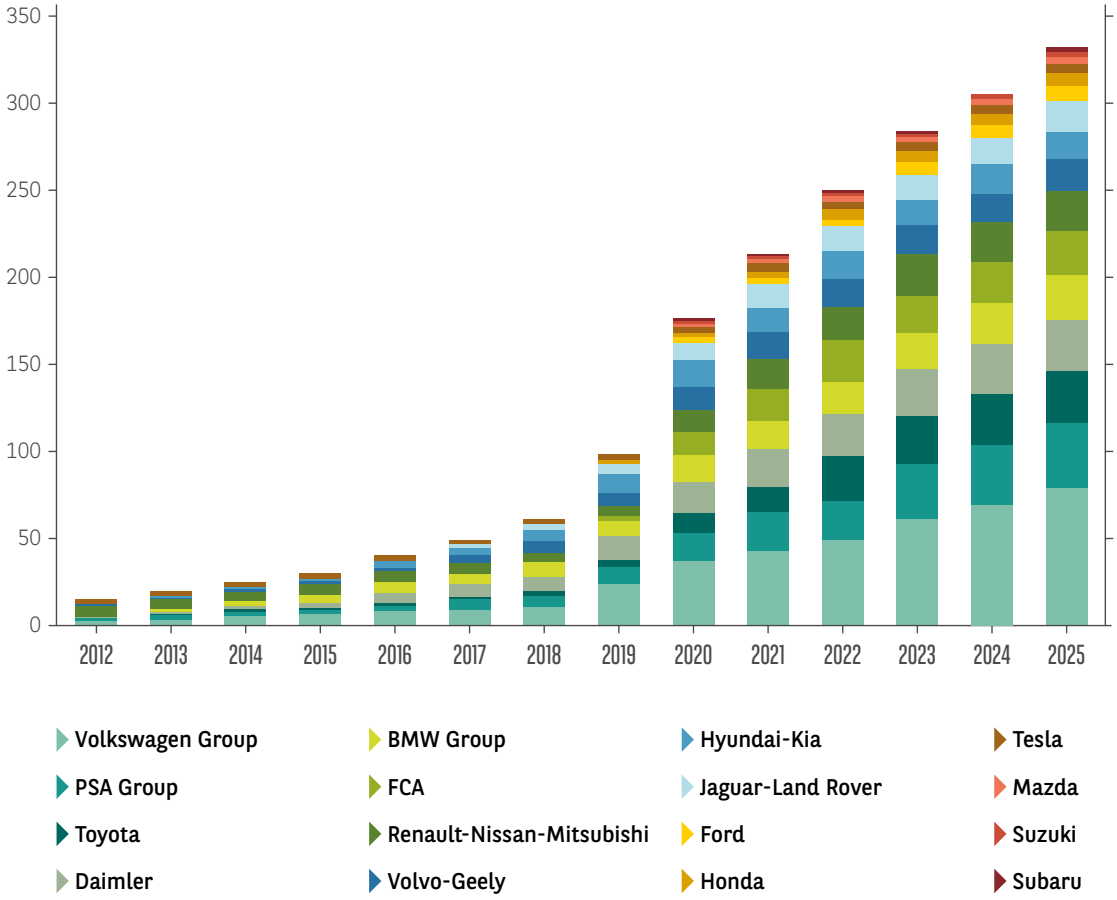
This powertrain outlook is also reflected in the number of corresponding models that car manufacturers have announced that they will bring to the market as illustrated in Graph 2. **Around 220 electric vehicles will be available in 2021 which is nearly 4 times the number of models that were available in 2018**. And in order to achieve the 2025 CO_2 targets, it is expected that this will grow to more than 325 models.

Graph 1: European registrations forecast per energy group type
Source: LMC Automotive



1 | INTRODUCTION

Graph 2: Electric car models (PHEV, BEV and FCEV) coming to the market in Europe
(source: Transport & Environment)



There is a **growing market demand for electrification**. Registrations, in Western Europe, of Diesel passenger cars fell from 55% in 2016 to 31.6% YTD in November 2019, mainly in favour of Petrol cars due to concerns over air quality. While Diesel registrations are, globally, more or less stabilising, Petrol registrations are expected to start falling and this time in favour of electrified vehicles. Governments are changing their tax incentives to increasingly favour cleaner and greener technologies. Low Emission Zones (LEZ) are being introduced, whilst electric charging infrastructure is growing rapidly and battery costs are steadily reducing.

At a time where there is growing public and political pressure to tackle the causes of climate change and air pollution, together with the increasing number of electrified models available, means that fleet decisions around powertrains have gone beyond functionality, performance and costs to include emissions and compliance criteria to ensure a future proof car mobility.

2 | REGULATIONS AFFECTING POWERTRAIN TECHNOLOGIES

Car manufacturers are confronted with **2 important obligations**:

1-Euro Emission Standards

2-CO_2 Targets

Euro Emission Standards

Independent on-the-road testing has clearly shown that **NOx emission levels from Euro 6b or older Diesel cars were up to 7 times higher than the existing Euro 6b standard of 80 mg/km**.

Consequently, and also in recognition that on-the-road fuel consumption varied significantly from official test figures, the outdated NEDC (New European Driving Cycle) lab test has been replaced by more realistic WLTP (World Harmonized Light-Duty Vehicles Test Procedure) and RDE (Real Driving Emission) tests. Considering the high levels of NOx produced by all Diesels with a Euro Emission Standard of 6b and older, the Regulations allow for a phased reduction of a maximum deviation of the initial NOx standards measured under Real Driving Conditions and this is called a Conformity Factor.

Although this has resulted in the production of the cleanest Diesels ever, ultimately affecting the production costs, **they can still potentially produce more NOx than originally intended in 2015**.

Table 1: Euro norm NOx standards

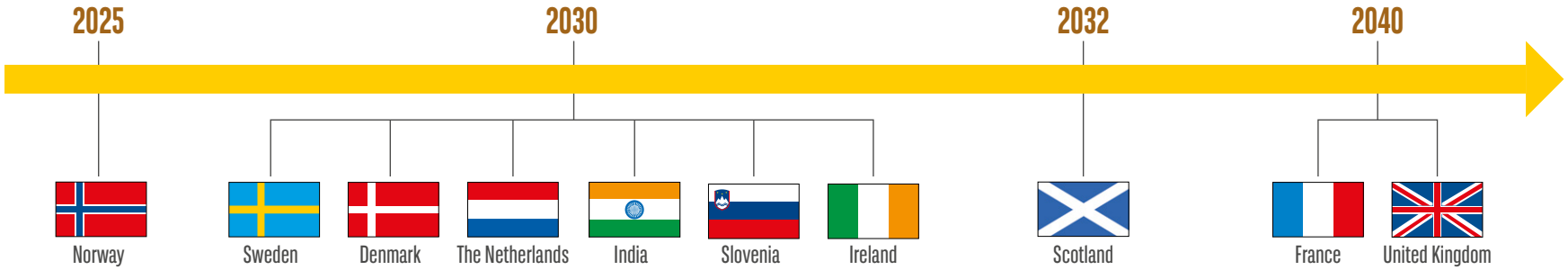
Source: several sources

EURO NORM	EURO 5A	EURO 6B	EURO 6C	EURO 6D-TEMP	EURO 6D
Test	NEDC	NEDC	WLTP	WLTP + RDE	WLTP + RDE
In place	Sept 2011	Sept 2015	Sept 2018	Sept 2019	Jan 2021
	No conformity factor existing as NEDC lab tests past the tests		No conformity factor as that relates to the RDE test	Conformity factor under real driving conditions of 2.1 allowed	Conformity factor under real driving conditions of 1.43 allowed
Petrol	60 mg/km	60 mg/km	60 mg/km	126 mg/km	85.8 mg/km
Diesel	180 mg/km	80 mg/km	80 mg/km	168 mg/km	114.4 mg/km

It remains to be seen as to whether cities such as Rome (2024) and Paris and Madrid (2025) actually introduce an outright diesel ban, however **at this stage Euro 6d ensures that drivers should have no real access restrictions in the near future in existing Low Emission Zones (LEZ)**. Also, with the exception of Norway, current proposed dates to end the sales of ICE cars will not start before 2030. Nevertheless, the question if and when there will be a Euro 7 emissions standard remains valid, potentially redrawing LEZ's access criteria.

2 | REGULATIONS AFFECTING POWERTRAIN TECHNOLOGIES

Picture 1: Proposed dates to end the sale of ICE cars
(source: Transport & Environment)



Achieving CO_2 targets requires electrification

As from 2021, the EU fleet-wide average CO_2 target for new cars is 95 g/km versus the actual emissions of 122 g/km in 2018, if measured in NEDC terms. An additional reduction relative to 2021 of 15% and 37.5% is required in 2025 and 2030 respectively using the WLTP result of 2021.

In order to achieve these targets and to avoid penalties, **car manufacturers have chosen to stop the production of their most inefficient or polluting vehicles, to invest in significantly greener ICE vehicles and to produce more electrified models**. In general, this strategy is considered to be cheaper or at least more sustainable than paying the penalty of €95 per gram over the limit. When multiplied by the number of cars they sell in 2020 this has been estimated by various sources to potentially cost up to €34 billion, which equates to about 50% of their aggregated Earnings Before Interest and Taxes (EBIT). As such it is not a surprise that manufacturers have to produce at least 8% Hybrids and 6% BEVs while especially Mild Hybrids and PHEVs will help them to reach the 2021 target.

2 | REGULATIONS AFFECTING POWERTRAIN TECHNOLOGIES

9%

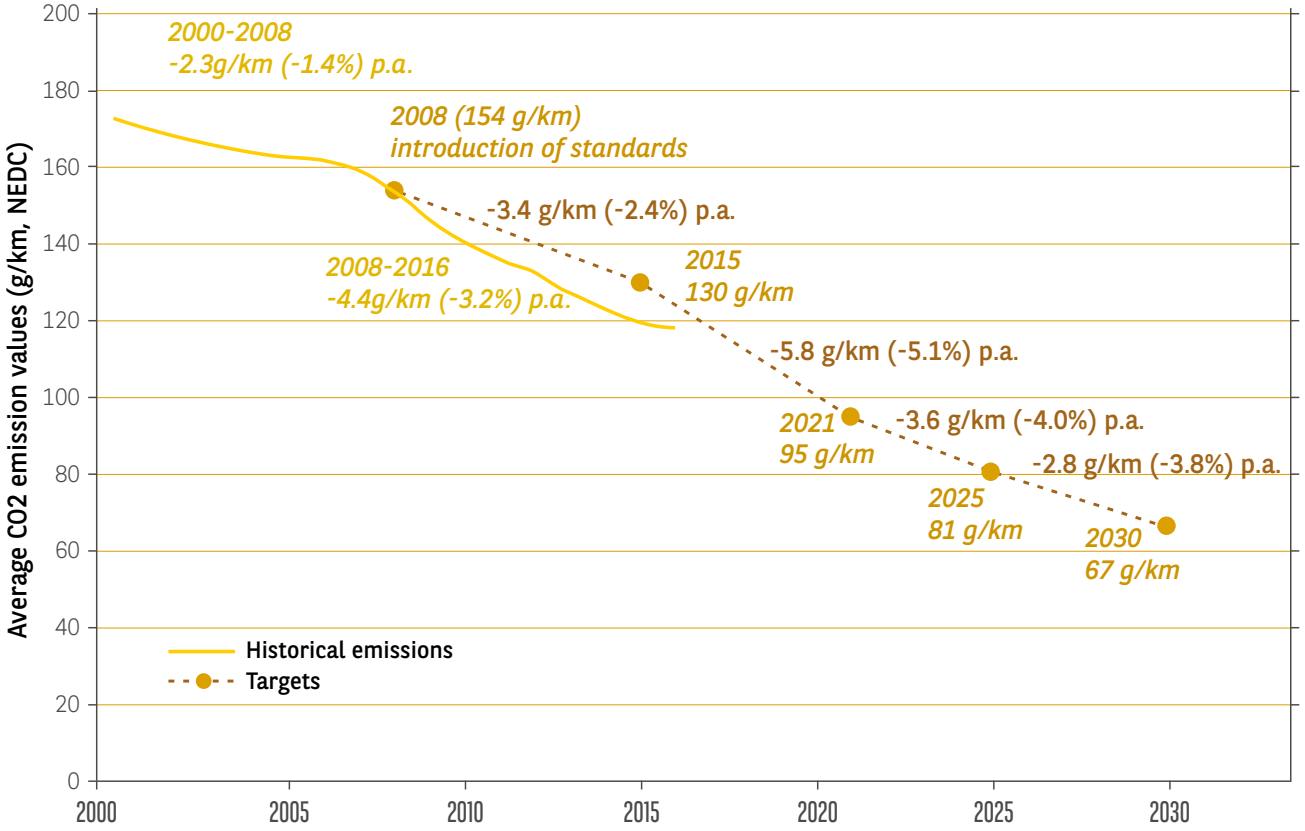
less CO_2 emitted by diesel car thanks to lower fuel consumption

by 2040

ICE vehicle may not be sold anymore in some countries

Graph 3: CO_2 emission from new passenger cars in the EU

(source: The Internal Council of Clean Transportation, ICCT)



Powertrain overview

New Petrol and Diesel vehicles are without a doubt cleaner, from both a NOx and CO_2 perspective, then ever before. Whilst diesel fuel emits about 17% more CO_2 per litre than petrol, diesel models typically emit about 9% less CO_2 per km than the equivalent petrol cars thanks to lower fuel consumption. Whereas, the Euro Emission standards for CO_2 are tougher for diesel, they allow higher NOx emissions than Petrol.

However, results published by the European Automobile Manufacturers Association (ACEA) in October 2018, highlighted that most of the newest diesels actually emit, in real driving conditions, a NOx level lower than 80 mg/km, with many closer to the lower Petrol level of 60 mg/km and below. Some institutions, such as the General German Automobile Club (ADAC - Allgemeiner Deutscher Automobil-Club) as well as the British Automobile Association (The AA) reported that a significant number of new Diesels emitted almost zero NOx. Obviously, more tests are required to fully confirm.

Nevertheless, the RDE conformity factor will reduce to 1 by 2023 meaning that the NOx difference between Petrol and Diesel will have essentially almost disappeared compared to a few years ago.

2 | REGULATIONS AFFECTING POWERTRAIN TECHNOLOGIES

As Hybrids combine a normal internal combustion engine and an electric motor, they have the potential to consume less fuel, less CO_2 and less NOx (or other particles) than its pure ICE equivalent.

Two main types of hybrid technology

MILD HYBRIDS (MHEV)

use an electric motor, generally utilising a 48-volt system (which cannot be plugged-in), to assist the Internal Combustion Engine. However, although it will not travel solely on electric power it offers greater fuel economy savings than the conventional start-stop function but less than a Full Hybrid.

Nevertheless, Mild Hybrids are easier and cheaper to produce and have a lower weight than Full Hybrids. Consequently, they have many of the advantages of Full Hybrids for a lower price. Unsurprisingly, as it is one of the cheapest and easiest ways to help achieve the 2021 CO_2 targets, OEMs will start to significantly increase their production offers as from 2021.

FULL HYBRIDS (HEVS)

have a very small battery, electric motor (that cannot be plugged in) and an ICE. It will travel a few miles on the electric power and will then switch back to the engine while a combination of the engine and regenerative braking will recharge the battery. As a result, they effectively consume about 25% less fuel, less CO_2 and less NOx (or other particles) than its pure ICE equivalent.

Plug-in Vehicles (PIVs)

Plug-in vehicles have much larger battery packs than conventional Hybrids which result in significantly greater electric driving ranges. Although they will self-charge in the same way as HEVs, in order to fully charge the battery, they must be plugged in. There are three main types of plug-in vehicle technology:

PLUG-IN HYBRIDS (PHEVS)

have a much larger battery, electric motor and an ICE. They have the capability to travel between 50-100km, (depending on the make and model) on electric power only, however they typically constantly switch between the motor and the engine depending on the road conditions and charge state of the battery.

As a result, PHEVs have great potential to significantly reduce both NOx and CO_2 emissions. However, this is strongly dependent on drivers routinely charging the car and fleet fuel policies that actively encourage this behaviour otherwise they can be less fuel efficient than pure ICEs due to their greater weight.

Despite being the most expensive hybrid option, thanks to their tax incentives, they are currently very popular and a steppingstone towards a Battery Electric Vehicle.

BATTERY ELECTRIC VEHICLES (BEVS),

otherwise known as full or pure electric vehicles (or more commonly just EV), have much bigger batteries and are powered only by electricity with no ICE.

Whilst BEVs will make use of regenerative braking to top up the battery and maximise the range, in order to fully recharge the vehicle, they must be plugged in. Depending on the model, BEV ranges are between 200km – 500km with a battery guarantee of 8 years or 160,000km for most models.

BEVs have no tail-pipe emissions which is extremely good from a local air quality perspective and although they are not completely zero emission, from a CO2 and NOx perspective, they are still more carbon efficient than the equivalent ICE vehicle which is discussed in Section 4.

THE EXTENDED-RANGE ELECTRIC VEHICLE (E-REV)

is similar to a PHEV in that it has larger battery than a full hybrid coupled with an ICE. However, the E-REV differs in that the motor always powers the wheels and the engine only acts as a generator to charge the battery and 'extend the range' of the vehicle. Although, like a BEV, the vehicle is run on battery power only it cannot be considered to be zero emission due to the tail-pipe emissions from the ICE.

3 | SELECTING THE OPTIMAL POWERTRAIN

3

tools to choose the optimal powertrain

Choosing the optimal powertrain today is no longer relatively straight forward; it is not only affected by the driver profile but also by the existing car policy reflecting the company's attitude and sensitivity towards Corporate Social Responsibility (CSR), the satisfaction rate of their drivers (or Driver Satisfaction Rate – DSR) and the Total Cost of Ownership (TCO).

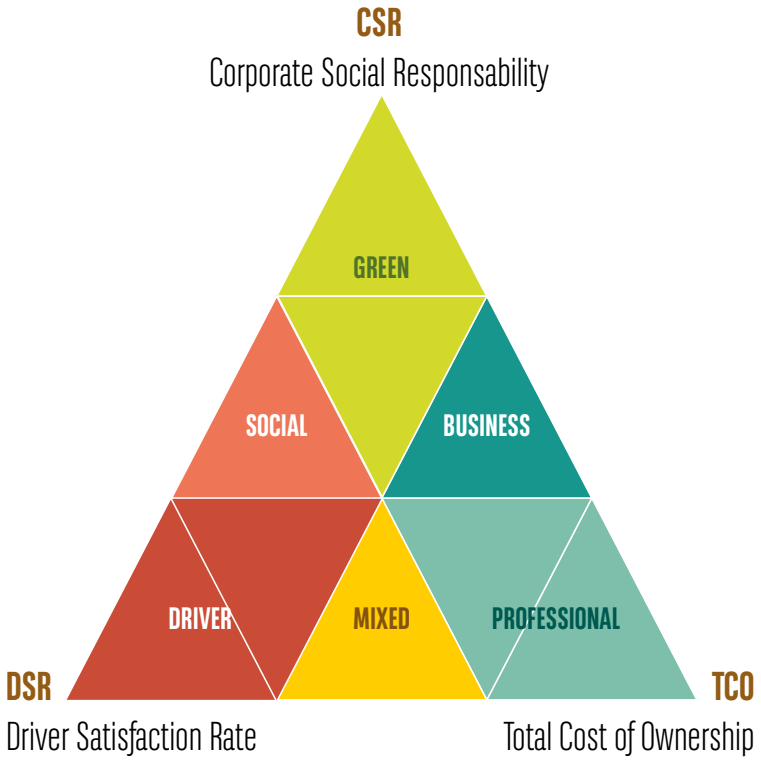
That's why Arval is using dedicated and in-house developed digitalized tools as part of our 5 step **Arval SMaRT (Sustainable Mobility and Responsibility Targets)** program to help our customers in making the right choices in their transition to greener and cleaner fleets and sustainable mobility including solutions allowing a shift from car leasing to wider mobility solutions.

Although in this paper we will not elaborate on the SMaRT approach itself, we will refer to some of our SMaRT Tools as they are directly relevant for helping selecting the optimal powertrain.

Client Profiling

Although all companies have an ambition to make their fleet greener and cleaner, they are also expected to manage the total costs of the fleet within budgets and to ensure that car choice contributes positively to employee satisfaction for retention and recruitment purposes. Consequently, it is important to understand clearly a company's sensitivity towards CSR, TCO and driver satisfaction as it may significantly influence the car policy and hence the choice of the final powertrain if there are a number of alternatives available for a driver.

Thanks to our **Arval SMaRT Client Profiling tool**, their prioritisation becomes clearer as the tool also offers a concrete strategy per profile (e.g. business) to making their fleet SMaRT-er.

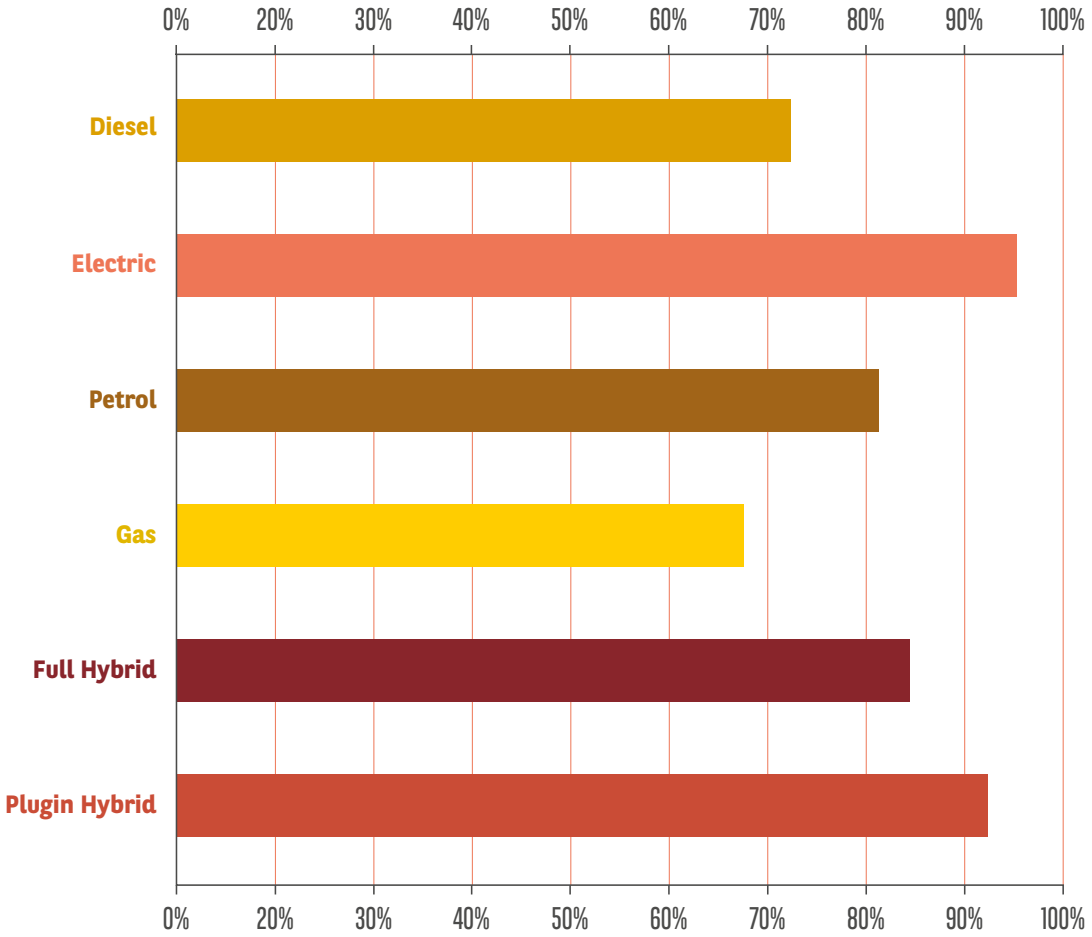


Picture 2: Arval SMaRT Client Profiling Tool

Driver Profiling

Depending on the usage of the car in terms of typical journey length, trip frequency, planned locations and ability to charge as well as the driving style of the individual it is likely that one powertrain is more favourable over another. Arval's SMaRT Driving Profiling tool helps illustrate which powertrain(s) would potentially be most suitable when considering the individual driving profile of the user.

▸ Picture 3: Powertrain Compatibility by Arval's SMaRT Driver Profiling Tool



SMaRT TCO Simulator

Thanks to our **SMaRT TCO Simulator**, we are able to provide a list of the optimal powertrain for each employee whilst respecting TCO budgets, CO_2 targets and ensuring driver satisfaction.

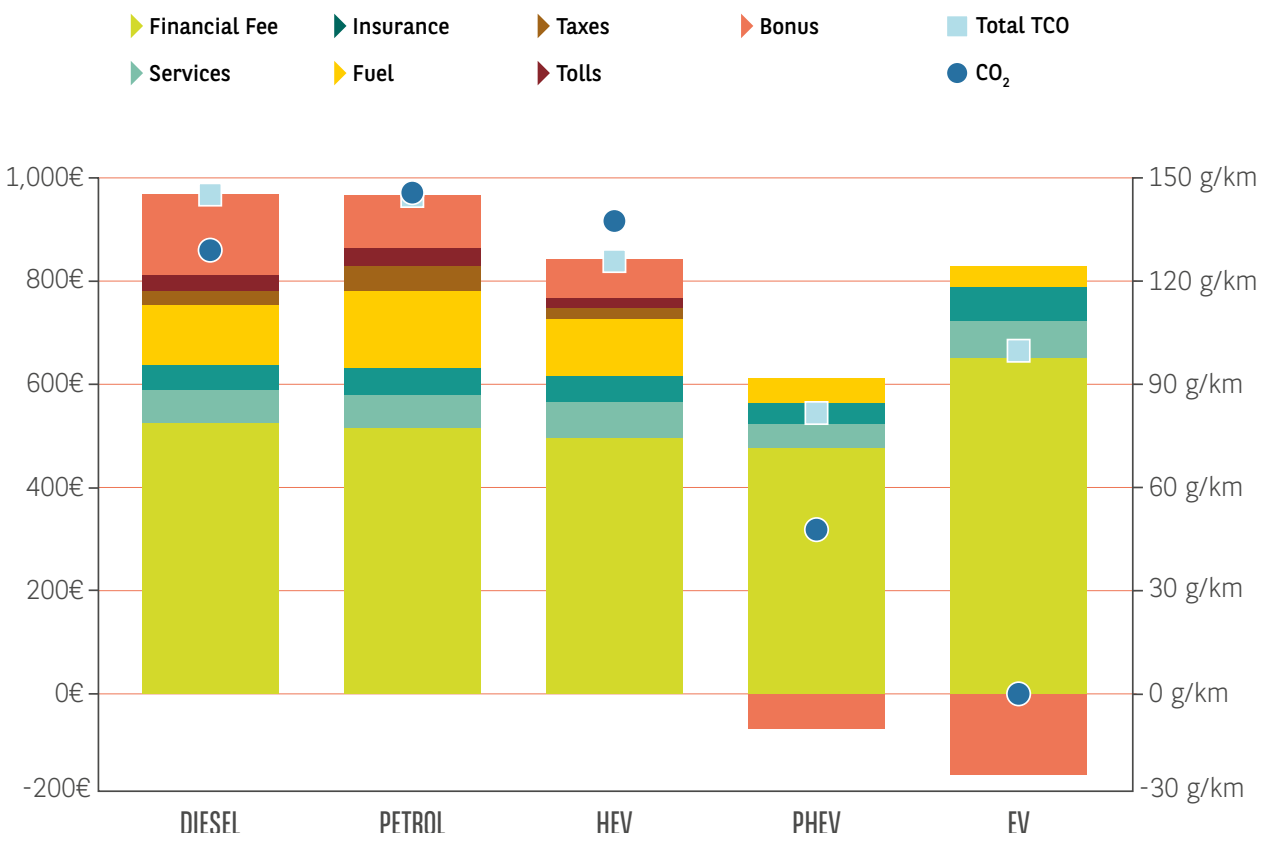
Arval's position on different powertrains

Whilst the latest ICE vehicles and other electrified options remain a valid option for many drivers, we will show that BEVs are not only a cleaner option, also satisfying high mileage drivers while offering significant advantages such as facilitating a much wider ecosystem, providing a higher interconnectivity increasing driver safety and easing the use of alternative mobility solutions. That's why Arval recommends that fleet operators prepare themselves for an accelerated shift towards BEVs over the next few years, particularly where there are strong personal tax incentives.

Obviously, a critical part of the TCO is the pricing by the leasing company itself (including the residual values set, the cost of maintenance and tires) along with the expected fuel consumption, insurance premium and taxes. In addition to the fact that we have adjusted our price levels for electric vehicles, we will argue in Section 4.4 that BEVs generally are becoming increasingly competitive from a TCO perspective.

In order to ensure that BEV driving is a feasible option, it is also important to have the right partnerships ensuring e-mobility such as charging facilities for which Arval can offer a full service package which we will elaborate in Section 5.

Picture 4: Arval's SMaRT TCO Simulator



4 | 10 REASONS TO TAKE BEVs IN YOUR FLEET

73%

CO_2 emission reduction by 2050 for the life cycle of a BEV

50%

year on year growth expected for BEVs over the next 5 years

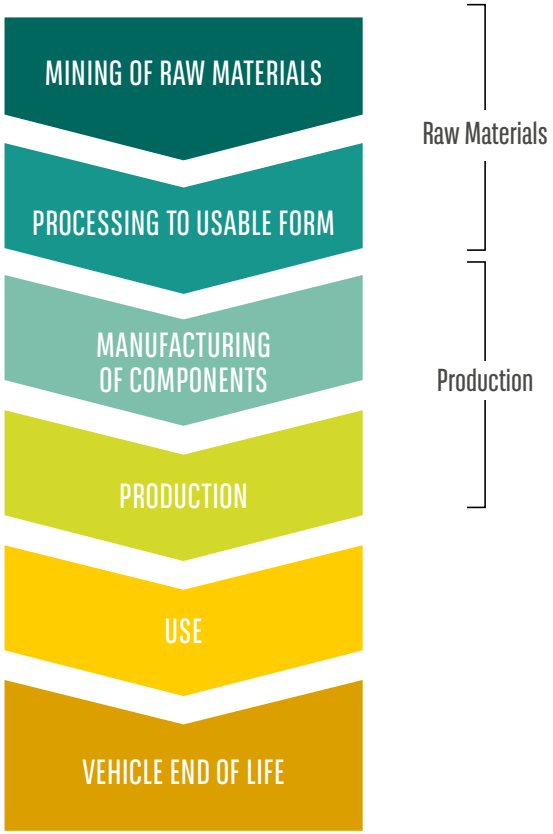
Though BEVs only achieved a 1.3% market share in Europe in 2018, still only accounting for a very small percentage of global new vehicle sales, this position is rapidly changing with continuous year-on-year growth expected of more than **50% each year over the next 5 years**. There are still many misperceptions around BEVs and so we have included 10 reasons why your company should consider starting the transition to BEVs into your fleet, progressively of course.

1 - BEVs are a greener option

Thanks to its zero tail pipe emissions, a typical BEV in Europe produces less greenhouse gases and air pollutants across its whole lifecycle compared with its petrol or diesel equivalent. Although the manufacturing carbon emissions for BEVs are in general higher, due to the battery production process, these are more than offset by the lower in-use emissions over the life of the car.

A report by the European Environment Agency, "Electric Vehicles from Life Cycle and Circular Economy Perspectives" shows that **BEV's CO_2 emissions are about 17%-30% lower than ICE's emissions over the entire vehicle life cycle** and with the current EU energy mix. A 2017 European study conducted by VUB University in Brussels, on behalf of the NGO 'Transport and Environment', even reported an average gap of 55% less CO_2 than the diesel equivalent.

Picture 5: Total Lifecycle Assessment
(European Environment Agency)



4 | 10 REASONS TO TAKE BEVs IN YOUR FLEET

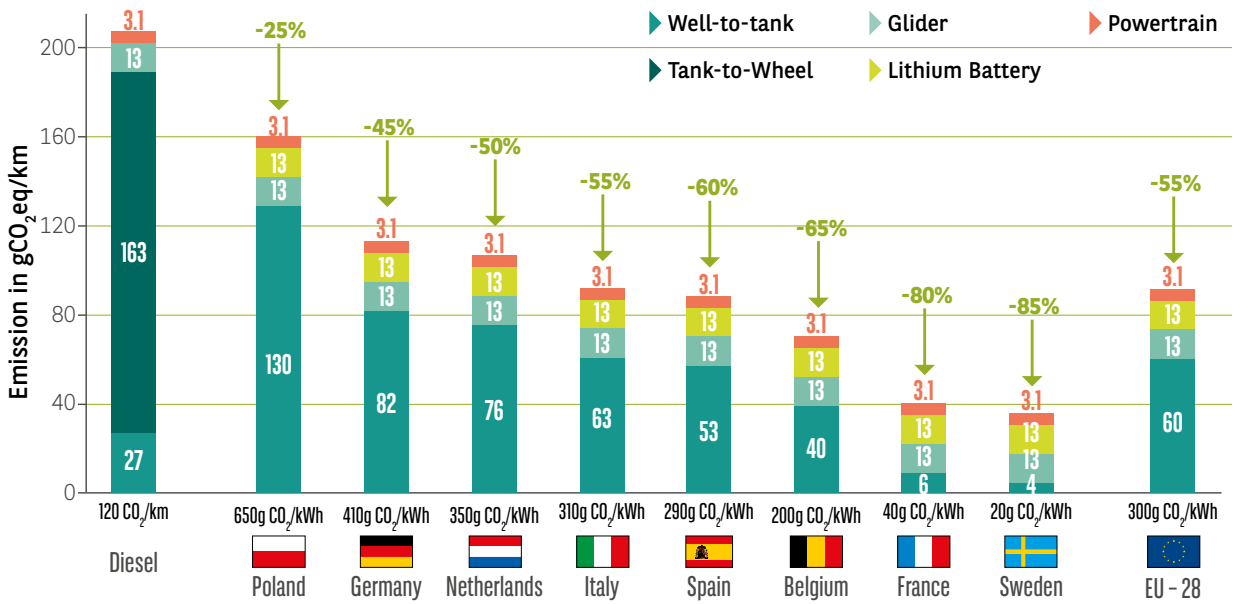
This varies from 25% less in Poland, still producing the "dirtiest" energy, to 85% less CO_2 in Sweden. In the appendix a total overview of EU countries is presented.

Although 22% of the current EU energy mix is still electricity generated from coal, the continual growth in renewable and low carbon sources, including nuclear, solar and wind power, means that carbon emissions will continually reduce. Considering the projected EU energy mix as coal is phased out, the life cycle emissions of a typical BEV could be cut by at least 73% by 2050.

Though BEV production impacts ecosystems due to the extraction and processing of nickel, copper and other critical raw materials, the report concludes that through a circular economy approach facilitating reuse and recycling of batteries, these impacts can be minimised. Obviously, the more batteries are used in second life applications and ultimately recycled, these ecosystem impacts will gradually reduce in time.

Graph 4: BEV CO_2 emission reduction when including electricity production in Europe

(source: Transport & Environment)



Although BEVs, like ICE vehicles, still produce particulate matter from road, tyre and break wear, **BEVs obviously do not produce any tailpipe NOx emissions** and so offer clear air quality benefits at a street and city level.

Although power generation also contributes to the overall CO_2 and NOx emissions, with power stations being typically located away from population centres, means **that their contribution to roadside and city centre emissions is slight in comparison to diesel vehicles or ICEs in general and will reduce even further when energy generation gradually becomes cleaner.**

Last but not least, a shift to BEVs will also reduce noise pollution, even after including the Acoustic Vehicle Alert System (AVAS), a mandatory artificial driving noise for security purposes, especially in cities where in general vehicle speeds are low and traffic often stands still.

The French Arval Mobility Observatory (AMO) with the help of Eurogroup Consulting, to ensure independent objectivity and impartiality, has undertaken research to explore this subject in more detail and to better understand the full environmental benefits and impacts of BEVs. This research has resulted in the publication of "Le véhicule électrique est-il si vertueux?" which is available at **https://mobility-observatory.arval.fr/le-vehicule-electrique-est-il-si-vertueux**.

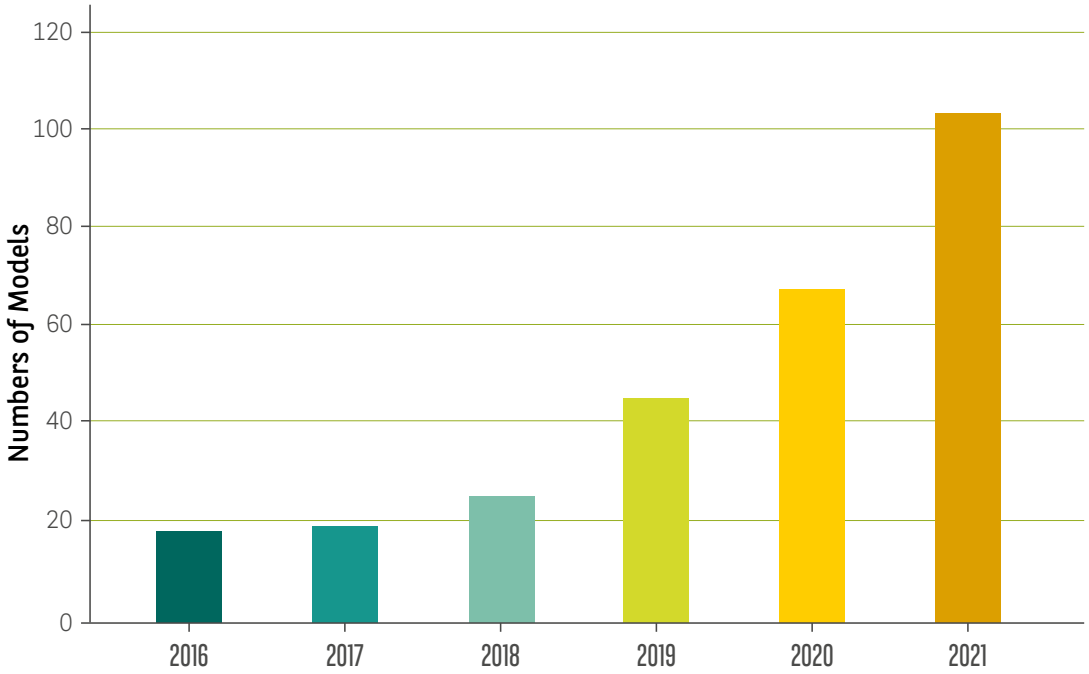
2 –BEVs provide a wide range of new models

To date, one of the main barriers to plug-in vehicle take-up has been the limited number of models available, particularly with regard to certain vehicle segments (i.e. lower medium estate etc.), coupled with the electric range capability for BEVs. However, in the next two years, the number of **BEV models is expected to rise to more than 100 which is a five-fold increase from 2018**.

As a result, **BEVs will be available in all segments** including Small & City Cars (e.g. Fiat 500e, Peugeot 208, Opel Corsa), Compact Cars (e.g. Peugeot 308, Volkwagen I.D.3, Citroen C4), Large Cars (BMW iX3 series, Tesla Y, Audi Q4), Luxury Cars (e.g. BMW i4 series, Audi e-tron, BMW iNext). A non-exhaustive list is presented in the appendix.

▸ Graph 5: Battery Electric Vehicle (BEV) models on the market are expected to increase five-fold by 2021

(source: Transport & Environment)



300km

is the average range of BEV today

3 – BEVs allow for high mileage drivers too

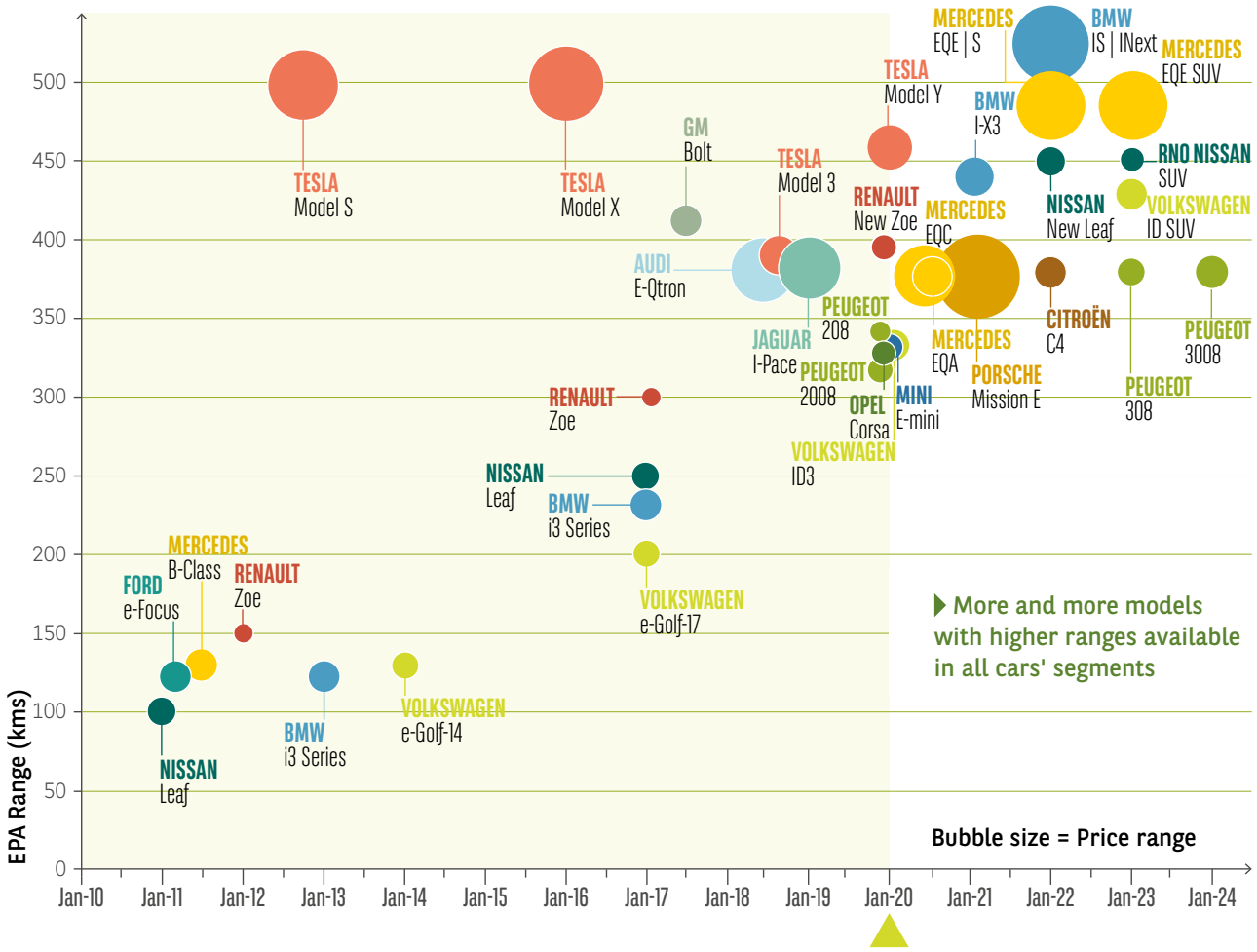
Whilst there is clearly a significant variance between individual models, data from the Electric Vehicle Database[3] highlights that the **average real-life range for all current BEVs is approximately 300km and even is 400–500km for some upcoming models**.

This is significantly different to the range of early BEVs, which was more like 80 – 120km, and transforms the accessibility of BEVs. A 300km range is undoubtedly less than the +600km that is more typical in an ICE car, however in reality most people do not regularly drive 300km (which equates to around 4 hours of driving) and even this is far greater than they will need on a day to day basis.

Ultimately public charging, which we cover in Section 4.7, enables drivers to extend the range of a BEV and alternatively complementary mobility services such as Arval Car Sharing, Vehicle Switching solutions.

Picture 6: Increasing battery range in km

(source: Exane and updated by Arval based on information at our disposal)



3 | https://ev-database.uk/cheatsheet/range-electric-car

50%

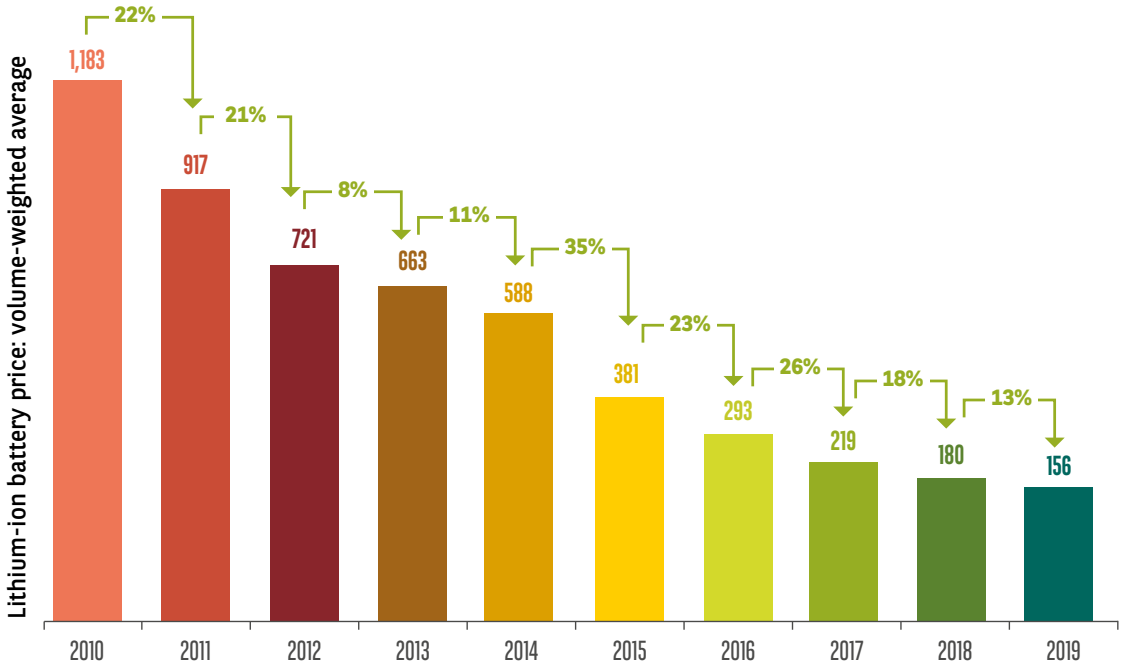
cost reduction expected for batteries by 2025

4 – BEVs have competitive TCOs

The combination of technological evolution, fiscal environment, willingness of OEMs to push BEVs, much less maintenance required, a potentially lower insurance cost and the energy efficiency of the electric powertrains all contribute to making the Total Cost of Ownership increasingly competitive. It should be noted that TCO parity has now been reached in several geographies for a number of vehicle segments and we expect this to accelerate further.

Graph 6: Evolution of battery pack price between 2010 – 2019 in $/kwh

(source: Bloomberg NEF)



REDUCING LIST PRICE AND INCREASING RESIDUAL VALUES ARE SUPPORTING ICE – BEV TCO PARITY

It is often considered that **price parity between petrol or diesel vehicles and BEVs will be achieved when the price of the battery pack reaches $125-100/kWh**, although this is very much dependent on the vehicle segment and the size of the battery that is incorporated into the vehicle. Conversely, it is still relatively early days for battery development in terms of the technology maturation curve as production volumes and R&D investment rapidly increases. As a result, economists now believe that today's **battery costs could be cut by more than 50% by 2025 and based on an average annual decline of 20.5% in graph 6, this price level should be reachable in 2 years**. To put this into context we can see how much prices have changed from the Bloomberg New Energy Finance survey, which has been following the price of batteries since 2010 (around $1,100/kWh) and currently predicts the price to reach $87/kWh by 2025 and $62/kWh by 2030.

On the other hand, though costs relative to petrol and diesel and standard hybrid vehicles have been relatively static, increasingly stringent emissions regulations will potentially make these progressively more expensive.

On top of this, **residual values of BEVs are expected to be higher than their ICE equivalents** due to shifts in demand and supply.

4 | 10 REASONS TO TAKE BEVs IN YOUR FLEET

10M+

new charging stations to be installed by 2030 (private and public)

FISCAL INCENTIVES ARE EXPECTED TO INCREASE FURTHER

Fiscal measures to stimulate electrified vehicle sales are available in 24 out of the 28 EU states and are expected to increase further, driven by Climate Act discussions and agreements. However, it should be noted that as the BEV market improves over the next few years and becomes more mature, then fiscal incentives such as the UK plug-in car grant will undoubtedly be reduced and ultimately removed.

EXCEPT FOR TYRES, BEVS TYPICALLY REQUIRE SIGNIFICANTLY LESS MAINTENANCE

There is some evidence to show that tyre wear on BEVs is greater than on ICE vehicles as they are heavier and have more power and torque, however the lower maintenance costs easily off set this effect.

BEVs typically require significantly less maintenance than ICEs because **BEVs have considerably fewer moving parts and fluids to change whilst the battery, motor and associated electronics basically require little to no periodic maintenance**. However, whilst brake wear is considerably reduced, due to regenerative braking, this does potentially result in increased brake rust or corrosion from the lack of use. An annual service to clean any corrosion off the brakes is therefore recommended. The batteries are also designed to last for the lifetime of the vehicle and in practice we know that even after **8-10 years, a battery's capacity is still at least 70% -80%**. After all, most providers provide a battery guarantee of 8 years and 100,000 – 160,000km.

INSURANCE COSTS ARE EXPECTED TO BE SLIGHTLY LESS THAN ICES

Despite the fact that BEVs face increased media scrutiny when catching on fire, the National Highway Traffic Administration, an agency of the U.S. Federal Government, stated in 2017 that there is **no evidence to conclude that BEVs start to catch fire faster than ICEs**. More, the likelihood for fire and explosion are anticipated to be somewhat comparable to or perhaps slightly less than ICEs. Although it is true that once they catch fire they are lost, using Tesla's data, CNN Money reported that Tesla fires occurred at a rate of 5 per billion miles travelled compared to a rate of 55 fires per billion miles travelled in gasoline cars.

When it concerns the frequency and average cost of damage, relying on actual insurance data, there is no real material difference between BEVs and ICEs while it is plausible to expect that frequency will reduce as drivers are getting used to BEVs in time.

RUNNING COSTS ARE CONSIDERABLY LOWER

Although BEVs are currently more expensive to buy than ICE vehicles this is offset by their significantly lower running costs. **Electricity is much cheaper than petrol or diesel** and so the costs / km are considerably lower even when charging up at public charge stations.

Obviously, the actual cost per mile / km will vary by country and charging location (home vs public charging) but typical costs are in the region of £0.04 per mile in the UK or €0.06 / km in the Netherlands.

5 – BEVs offer a more pleasant driving experience

Obviously, a driving experience is subjective. Nevertheless, there are arguments why BEVs really can offer a more pleasant driving experience.

The smooth and nearly silent efficient electric motors make BEV driving a much quieter, more comfortable and generally less stressful experience.

For the traditional car fans who value performance, the instant torque and zero revs in a BEV, even in the lower cost models, gives the driver **an impressively quick acceleration** compared to equivalent ICE models, taking the strain out of both city and extra-urban driving. The ability to smoothly and easily nip into gaps in congested traffic or accelerate to overtake on dual-carriage ways and motorways reduces some of the stresses in driving.

BEVs can also potentially handle better than ICE vehicles; the heavy weight of the batteries means that they are fitted to the floor which helps to give BEVs **a low centre of gravity and great balance**.

And on top of this, the lack of a transmission tunnel between the seats also provides **additional cabin space**.

6 – Wide Ecosystem, BEVs as storage unit

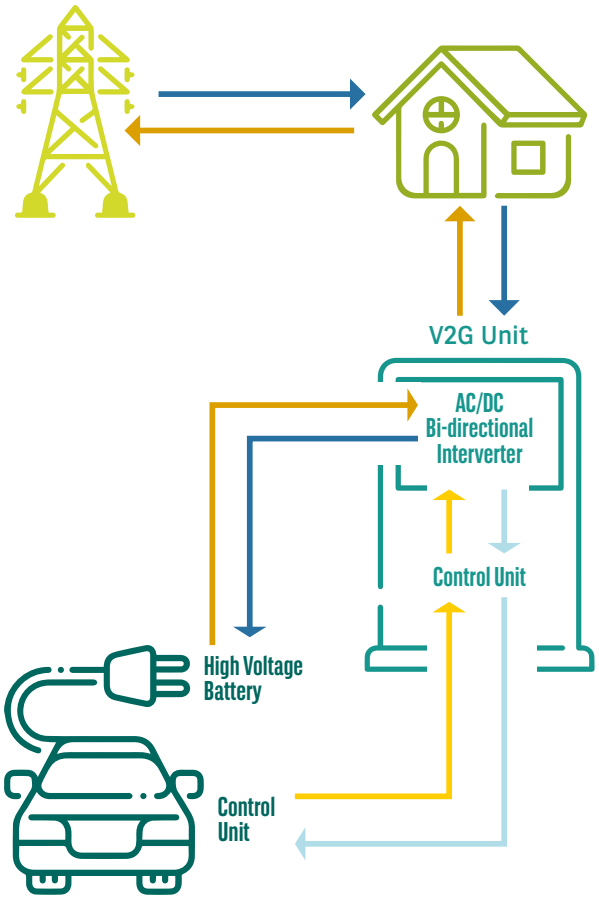
The growth of renewable energy (which by its nature is intermittent) presents energy management challenges due to the inevitable increase in volatility in energy generation.

Acting as decentralised storage units or energy reserves, which can be drawn upon by electricity suppliers through vehicle-to-grid technology[4], **BEVs are seen as a potential solution to help balance energy production and consumption**, to maintain grid stability particularly during peak hours. The ability to store electricity when the rates are lower and then sell it back to the Grid when the rates are higher further improves the TCO of a BEV.

This is certainly a valid case as studies show that most vehicles aren't typically in use for up to 95% of the time, hence an electric vehicle is as such an untapped power source ready to be explored.

Eventually, recharging a vehicle usually takes place upon arrival at home overnight or at the office during office hours (which in total account for 80 - 85% of recharging) which implies that driving to a charging station is rarely needed anymore.

Picture 7: Vehicle to Grid
(source: Fleetcarma, division of GEOTAB)

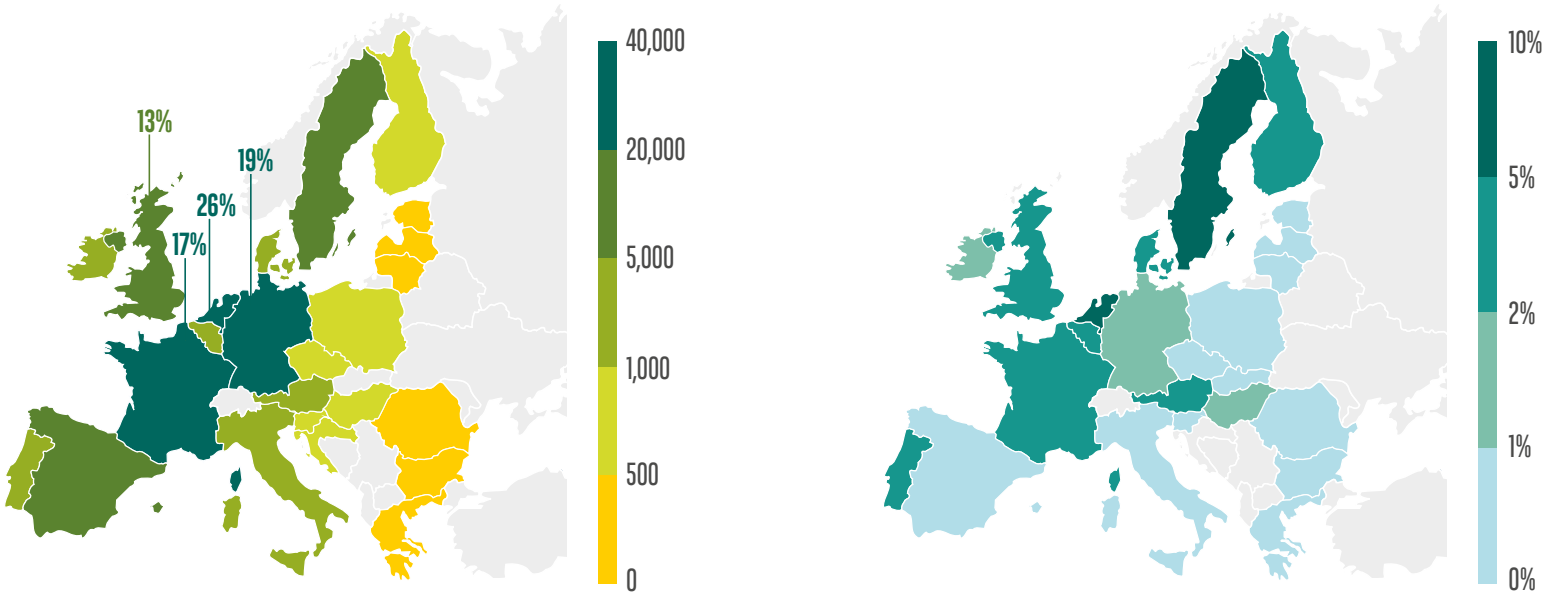


4 | a system in which there is an electrical energy flow between battery electric cars (BEV) and the power grid.

4

EU countries gather 76% of the charging stations in EU

Picture 8: Electric Vehicle Charging Infrastructure and Market Share of Electrically-Chargeable Vehicles (ACEA)



Like the growth in EVs themselves, the global number of public charging locations has grown significantly in the last few years and is set to continue.

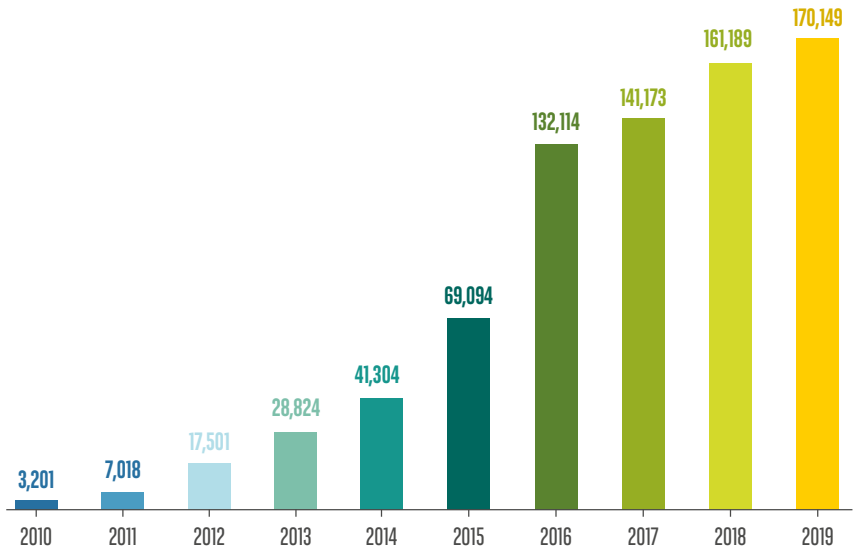
7 - Growing Public Charging Infrastructure

The European Automobile Manufacturers Association (ACEA) recently demonstrated the correlation between the market sales of EVs and the availability of charging points for all 28 EU member states. In general, **the more charging stations, the higher the EV market share** which is clearly visible for the Netherlands, Sweden, France and the UK. And except for Greece or Romania, the fewer charging stations, the lower the EV penetration.

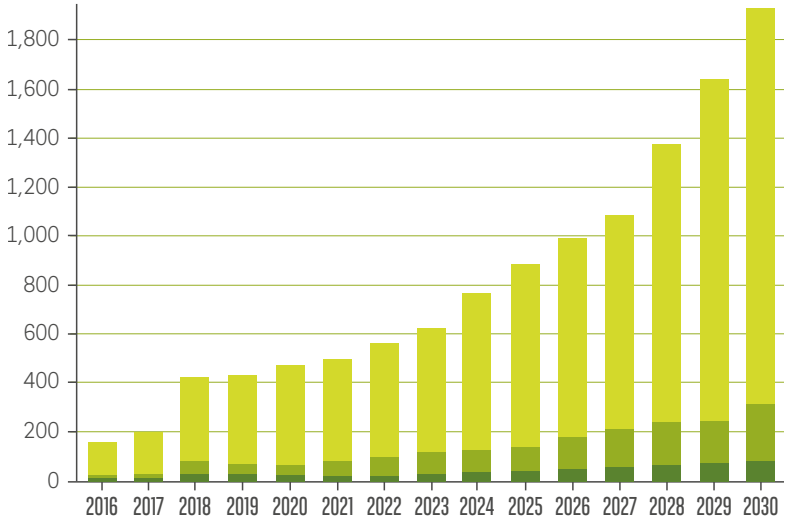
Currently, **76% of all charging stations in the EU are located in just four countries** (Netherlands 26%, Germany 19%, France 17% and United Kingdom 13%) and in EU in total there are 170,000 charging stations versus 122,000 fuel stations, though a fuel station has more fuel pumps.

4 | 10 REASONS TO TAKE BEVs IN YOUR FLEET

Graph 7: number of public charging stations in Europe
(source: Statista)



Graph 8: Annual investment in public charging infrastructure in million €
(source: Transport & Environment)



- **Front-runners** are most Western and Nordic countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, Sweden and the UK
- **Followers:** Italy, Portugal and Spain
- **Slow Starters** composed of EU13 and Greece: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia

According to Greentechmedia, **Europe is expected to set in operation 9 million residential and 1.6 million public charging points by 2030** and according to Transport & Environment, the total investments in public charging will increase from 400 Million in 2018 to about 2 Billion in 2030. This investment will differ from country by country but can basically be categorized into 3 groups:

The ability to charge at home or at work has transformed the re-fuelling requirements and behaviour of drivers and as a result **the use of public charging will generally be to 'top up' rather than to 'fill up'**. BEV drivers develop a different mind-set and a stop at a charge station will be to get sufficient 'fuel' for the journey rather than to fill up the 'tank'. Although the idea of visiting a fuel station will still happen, it will be much less frequently and will be **combined with other activities** such as shopping, having food or quality time with family, friends and colleagues as well as having off premises business meetings with clients and partners.

Most rapid chargers are currently 50kWh though there is a growing network of 'Super Chargers' with the ability to deliver 100kWh or 150kWh. Taking an average EV efficiency of 6km / kWh then **a 15-minute charge from a 100kWh charger will provide approximately 150km of additional range (depending on the model)**. A more useful measurement, rather than the time taken to charge to 80% which is routinely reported, would be the range added (in miles or km) per minute based on different charging speeds.

8 – Future proof access in ULEZs and Diesel banned cities

Cities and governments have been implementing Low Emission Zones (LEZ) and Ultra Low Emission Zones (ULEZ) to restrict the access to cities and larger towns of the more polluting vehicles as a measure to reduce emissions of NOx and fine particles.

LEZs are currently implemented in various cities across Europe, and a comprehensive overview can be found at **https://urbanaccessregulations.eu**. This also includes details of other types of vehicle access restrictions such as congestion charging as well as future planning.

Although Euro 6d is currently considered as a risk-free vehicle to enter existing LEZs, one should consider that some major cities (such as Rome and Paris from 2024 and Madrid from 2025) have announced **plans to ban all diesels**. Due to their zero tail-pipe emissions, **BEVs are not affected by LEZs or city bans which makes them a future proof option**.

9 – BEVs are more connected

A connected car is able **to share internet access and data with other devices, networks and services both inside and outside of the car including other cars, charging infrastructure, home and office**. Through this connectivity the car can easily provide traffic congestion, safety and collisions alerts. It can also, when connected to the driver's calendar, alert the driver of the time to leave and inform colleagues, friends, parking and charging facilities on their arrival time.

With a BEV, infotainment, safety, contextual help offers, navigation and efficiency diagnostics, and payments reach a new standard and opens doors for further WIFI connection to passengers together with vehicle to vehicle and vehicle to infrastructure opportunities.

10 – BEVs are trendy and responsible

Last but not at least, a BEV, packed with latest technology, is not only in line with the latest technology trends, it is also the most responsible choice to take.

5 | CHANGING YOUR FLEET TO A BEV FLEET

8

steps to greener and cleaner fleet

Replacing an individual ICE with a BEV is one thing, but successfully transitioning a whole fleet to electric over the next few years is a much bigger challenge and is much more than a pure top down decision. Some Fleet Managers, through a lack of experience with the technology, might be daunted by this and have real concerns on how to effectively manage the growth of BEVs in their fleet.

Arval is ready to help the Fleet Manager in making this transition and can ensure that by following our 8 steps approach, a greener and cleaner fleet becomes a feasible objective.

1 – ORGANIZE INFORMATION SESSIONS ON EVS

Considering our habits of driving an ICE vehicle, it is normal that there is (some) reluctance to drive a BEV or that interested people are left with a lot of questions. Our experience shows that it is beneficial to organize information sessions in cooperation with your leasing company and manufacturers or dealers and to allow test drives for employees.

2 – THE RIGHT VEHICLE FOR THE RIGHT DRIVER

The BEV should be suitable for the driver. Understanding driver profiles including driving mileage patterns, driving style as well as checking to see if they can charge at home, at the workplace or easily access public charging stations to mention a few can be executed by a simple questionnaire (such as Arval's Driver Profiling tool), using driver profiling apps or by using Arval's telematics solutions.

3 – EDUCATING THE DRIVER

New technology requires a user guideline. Having dedicated information sessions are certainly recommended to help users:

- Planning the journey and corresponding range needs
- Smart charging and vehicle preparation before leaving
  - e.g. pre-conditioning temperature while charging, charging in the garage during cold temperatures
- Learning how to avoid wasting energy before even starting the journey
  - e.g. unnecessary loads, too low tyre pressure
- Optimizing their driving style to maximise the battery efficiency and range
  - e.g. eco-driving, speed limitation alert, cruise control, range monitoring,
- Becoming familiar with (rapid) charging locations, accessibility, payments and timings
- Learning how to care for the charging lead and the battery

Educating the driver in how to optimize their e-mobility will help fleet managers to make the BEV decision work effectively.

5 | CHANGING YOUR FLEET TO A BEV FLEET

4 – CHARGING INFRASTRUCTURE

Developing a strategy around charging infrastructure is a key action to undertake in the fleet transition to BEV to ensure that all drivers can charge their vehicles adequately. As well as setting reimbursement policies, it should consist of decisions around investment in charge point facilities at the office premises, together with providing home charging solutions and enabling easy access to public charging.

Thanks to our full e-service package including charging solutions, telematics or real time data sharing (by the vehicle or mobility apps) and your own fleet's data can be used to define and optimize the charging infrastructure strategy as a continuous learning and feedback cycle.

5 – BUILDING A BEV COMMUNITY

Encouraging and sharing best practice together with feed backing ideas for improvement are all examples how individual successes can be used as a leverage to increase the BEV transition and to help change attitudes and driving patterns.

6 – BENEFITING BEV DRIVERS

Benefiting car drivers is another example that will encourage drivers to truly adopt an efficient and effective BEV driver habit. Examples can be sharing, in some form, a part of the fuel consumption and emission cost reductions or alternatively by e.g. gamification granting the best BEV use performance by incentives.

7 – PLAY THE FLEET BEV METRICS

New utilization, cost and benefit metrics are there to monitor and to manage in order to allow you to optimize fleet running costs and consolidate driver performance including maximizing driving range and charging behaviour using charging reports, diagnostics efficiency (car diagnostics, predictive prognosis, heat reports, parking apps etc.) and/or real-time information to re-loop it into our step approach, increasing the BEV maturity and to make optimal decisions about your BEV fleet.

8 – ARVAL'S E-MOBILITY SERVICES

Arval has developed a total offer to support customers in defining and implementing their energy transition strategy with a comprehensive solution facilitating the adoption of Electric Vehicles:

- The first step is identifying when an EV is most appropriate based on how and where the vehicle is used, as well as how and when it can be recharged. This is based on our SMaRT approach allowing for the fleet analysis, electrification potential definition and enabling the right EV suggestion.
- The next step is ensuring convenient charging solutions at home or at office locations that can be bundled together with optional green energy as part of the EV operation leasing as well as a payment card for public or partner networks supported by a mobile app for availability of public charge points and pricing. The automatic energy refund for home charging is included making it easy for companies and fully transparent for employees to switch to an EV.
- Furthermore, several services have been designed to support flexibility and overall BEV adoption. These include providing a conventional vehicle (ICE) replacement for short period like holidays enabling long trips for those won't willing to do it with their BEV. It also includes BEV trial periods of several months to try electric mobility for longer durations with no penalties if such a vehicle is returned.

6 | CONCLUSION

New car offerings by OEMs are clearly, step by step, replacing oil with electricity and data. Choosing the optimal powertrains for fleets and individual drivers becomes more and more diverse and dependent on individual needs, corporate policies, changing tax environments and city access regulations.

Selecting the optimal powertrain is one thing; managing sustainably, the energy transition in fleets is another challenge. It requires a well-balanced combination of information, education, taking the right decisions and monitoring that ambitions are reached.

That's why Arval is at your disposal to help you to make this journey.

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Table 2: A non-limited list of new BEV models to be released

(source: announcements by Car Manufacturers)

SEGMENT	MODEL	PRE-SCHEDULED RELEASE PERIOD
Small and City cars	Fiat 500e (BEV) Skoda City Go (BEV) Peugeot 208 (BEV) Opel Corsa (BEV) Honda-e (BEV) Opel Mokka (BEV) DS3 Crossback (BEV) BMW Mini Peugeot 2008	End of 2019 2020 End of 2019 End of 2019 2020 2020 End of 2019 End of 2019 2020
Compact cars	Peugeot 308 (BEV) VW ID (BEV) Citroën C4 (BEV) Toyota C-HR (BEV)	2020 2020 2020 2020
Large cars	BMW iX3 series (BEV) Tesla Y (BEV) Merdedes EQA (BEV) Audi Q4 (BEV)	2021 2020 2020 2021
Luxury cars	BMW i4 series Audi e-tron (BEV) BMW iNext (BEV) Mercedes EQS (BEV) Jaguar XJ	2020 End of 2019 2021 2021 2020

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Table 3: Powertrain Comparison

	MILD & FULL HYBRID	PHEV	EV	HYDROGEN	NATURAL GAS
+	Lower emission/ consumption especially in case of Full Hybrid (-25% less)	Very low emission/consumption if charged well. Else higher emission/consumption than ICEs	Zero (tail-pipe) emissions	Zero (tail-pipe) emissions other than water vapour	Almost zero NOx and Particulate emissions
+	Growing choice (primarily Toyota & Lexus)	Electrification is the primary focus of OEMs which is resulting in a growing model choice		Refuelling takes 3-5 minutes	Reduced CO_2 and fuel consumption
+	Considered to be a mainstream technology	No 'range anxiety'	Fiscal benefits	Reasonable range (+480km)	24m vehicles on the road, very few in Europe
–	Optimum fuel economy may not be achieved on longer journeys	Limited electric only range (50–100km)	Limited range but steadily improving (+ 300km) and up to 500km for models coming within 2 years	Very expensive technology but should improve	Installation remains expensive, tanks require a lot of space
–	Impact of new WLTP tests is still unclear	Impact of WLTP new tests is unclear	Still relatively expensive though the decline of battery costs will reach the price parity with ICE quite soon	Very limited model choice	Very limited model choice
–		Charging infrastructure is relatively limited but (very) rapidly growing		Extremely limited refuelling infrastructure	Limited distribution network
✓	Better suited to urban / short journeys	Better suited to journeys less than 160km	Limited Daily Mileage depending on charging facilities	Potentially one for the long future	Some opportunities for commercial fleets

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Table 4: Diesel – Petrol Comparison

KEY FACTORS	FUEL TYPE COMPARISON
Emissions	
CO_2	Diesel has generally lower emissions thanks to their lower consumption and despite that the CO_2 emission per litre is about 10% higher than Petrol, but the difference with Petrol can now often be quite small 5–10g/km.
NOx	New diesel engines are considerably cleaner than previous versions. Though their 6d NOx norm is about 20% higher than its Petrol equivalent, RDE testing shows that for some cases the differences with Petrol are sometimes insignificant. Furthermore the introduction of RDE2 compliant models will make diesel and petrol essentially comparable by 2023.
Cost comparison	
List / lease price	Price premium for diesel models (€1k - €2k) which usually results in a higher lease cost.
Fuel efficiency	Diesel is usually significantly more fuel-efficient which results in lower fuel / running costs regardless of fuel price variations.
TCO	Lower fuel costs for diesel usually offsets the higher lease costs for a lower TCO. However, this varies significantly by make, model and mileage and so a car policy based on TCO and Driver Profiling will always ensure that the correct fuel type is utilised.
Future influencing factors	
Taxation	Taxation on diesel cars / fuel may increase due to Air Quality pressures which would increase the TCO. However, taxation on petrol cars / fuel could also increase due to CO_2 pressures.
Access restrictions	City centre access restrictions / charges will increase over time. Euro 6d is likely to be the primary criteria which and so minimal impact on fleets in the near future. However, full diesel bans are likely to gradually appear over time along with zero emission zones but the rate at which these are introduced is likely to be relatively slow. Additionally, a release of Euro 7 might change existing and future access criteria.
CSR	CSR pressure is likely to increase. Focus is likely to be on electrification rather than petrol or diesel.

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