



Promises, but no plans

How the EU can make or break
the transition to zero emission cars

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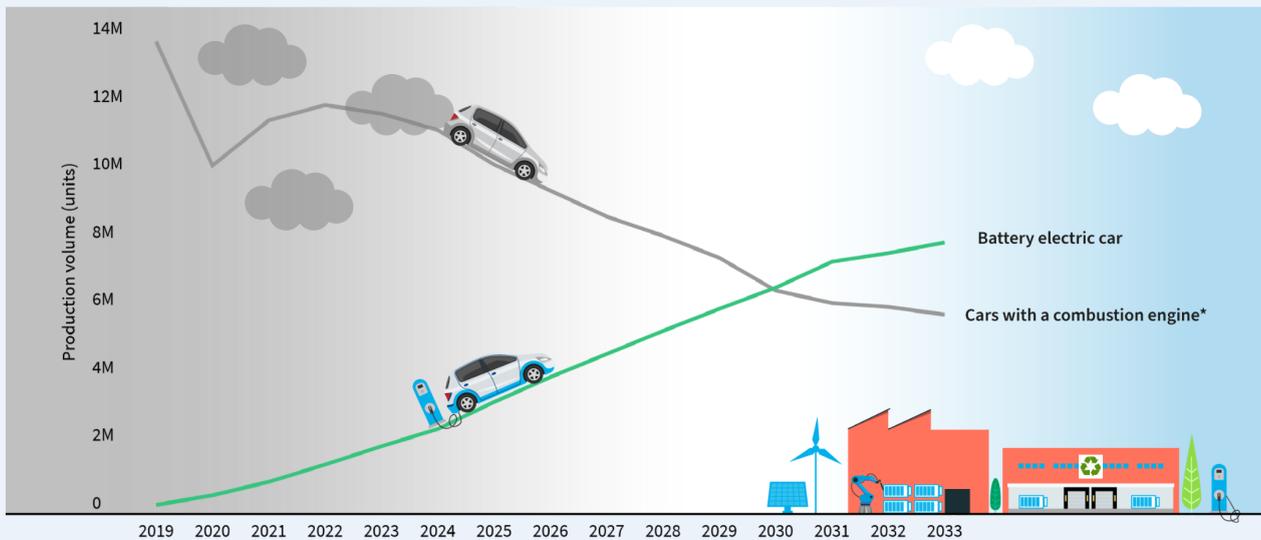
Executive Summary

Following the entry into force of the 2020/21 EU car CO₂ standards, electric cars (EVs) have stepped into the mass market much faster than previously expected, and fully zero emissions mobility is now within reach. The review of the car CO₂ targets coming as part of its far reaching climate package this summer represents the opportunity to accelerate this transition. But with many voluntary commitments from carmakers announced in 2021, the question is: what's the role of regulation given the carmakers' recent promises? T&E analysed the coherence of automotive EV plans and voluntary commitments with the EU Green Deal ambition to see whether we can rely on them alone to achieve our climate goals, and what's the role of the supply-side regulations like vehicle emission standards to get us to zero on time and with competitive industry intact.

Based on IHS Markit car production forecast, T&E has analysed current and future production plans of carmakers in Europe and assessed the ambition of their mobility strategies. Throughout the decade, BEV production is expected to ramp-up from around 1 million units in 2021 (7% of production), up to 3.3 million units in 2025 (a quarter of EU27 production) and 6.7 million in 2030, or just over half of all cars produced. Carmaker production plans in the EU27 + UK show that plug-in hybrid vehicle (PHEVs) production is expected to peak at 1.7 million units in 2025 -or 11% of total car production-, and stagnates at this level throughout the second half of the decade. Compared to 2020, the share of internal combustion engines (ICE, also including mild hybrids) produced would be cut by more than half in 2030 (from 88% in 2020 to 58% in 2025 and 32% in 2030). At the same time, full hybrid vehicles (HEVs) are expected to slowly grow but only reach 9% of the cars produced in Europe in 2030. Alternative technologies such as fuel cell electric vehicles (FCEV) or compressed natural gas vehicles (CNGs) will account for a negligible part of the car production: FCEVs would barely reach 40,000 units in 2030 (0.3% of the EU total production), while CNGs are expected to account for only 0.03% of the EU car production in 2030 (or 4,900 units). According to carmakers production plans, battery electric vehicles clearly appear as the only credible future-proof technology in the eyes of the industry.

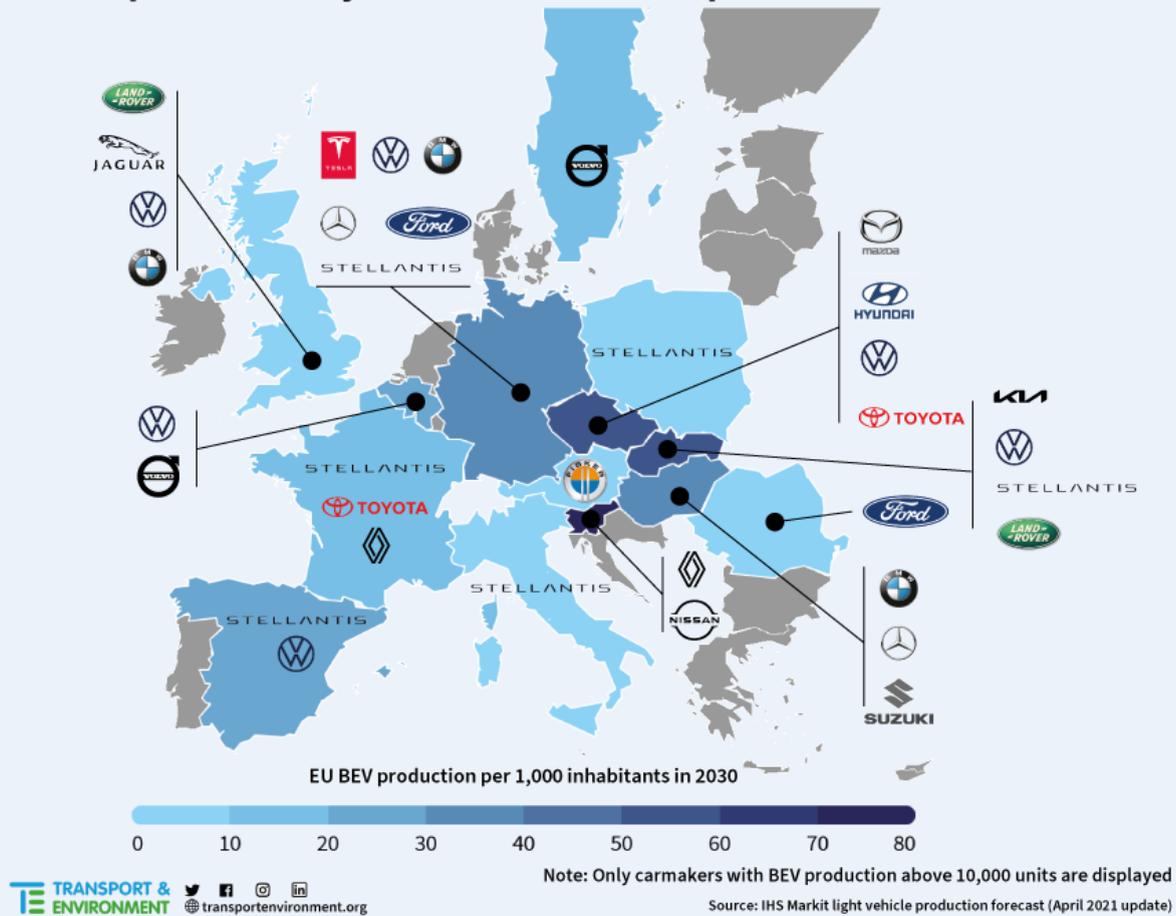


Battery electric vehicles become dominant in the EU production mix from 2030



The expected scale up of electric cars production is good news for the European economy: from battery and electronics manufacturing to the deployment of private and public charging infrastructure, wide industrial opportunities will arise. Western European countries such as Germany, Spain and France are forecasted to host the largest BEV production volumes. Central and Eastern European countries will also benefit: Slovenia, Slovakia and the Czech Republic are expected to have the highest level of BEV production per capita (50-80 BEVs produced per capita in 2030).

Europe's battery electric vehicles production in 2030



With the introduction of new CO₂ targets in 2020/21, the number of BEV models available on the EU market has surged from 25 models in 2019 to 75 models in 2021. This number is expected to jump again to around 175 models in 2025 as CO₂ targets get tightened again, highlighting that the European EV market is still driven by compliance with the CO₂ standards.

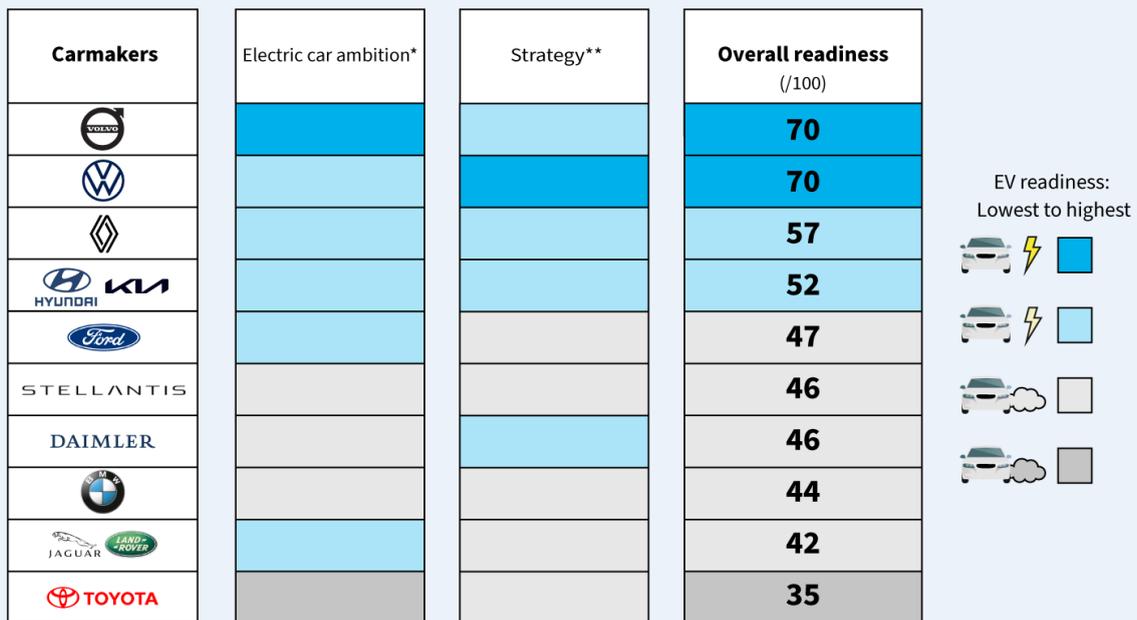
While Volkswagen Group and Stellantis would account for half of the total BEV production volumes in 2030 (with BEV mix of their total car production at 51% and 46% respectively), Volvo Cars and Ford are expected to have the highest BEV share in their production mix as they both target to phase out all ICES in Europe by 2030. On the other hand, all other major carmakers are still expected to produce more than one car out of two with a polluting engine, while Daimler would settle for only 34% BEV in their EU production mix according to IHS Markit forecast.

While these appear to be impressive plans, the reality is that much of it is the result of the expected tightening of the 2030 car CO₂ target in Europe to -50%, hence the announcements targeting this date. 2030 is far away and might mean that carmakers do little in the coming years. Less ambition or

commitments can be found for the mid-2020s, which is when the production and investments need to be ramping up to democratise electric cars across Europe and build on the current head start to compete with Asian and American competitors in the current race to zero.

To go beyond public announcements and analyse the readiness of 10 major OEMs present in Europe¹ towards the emobility era, T&E has developed its own **EV Readiness Index** looking into various strategies around EV architecture (e.g. platforms), technology mix, action in battery supply chains and infrastructure.

Carmakers electric vehicles readiness index



*Electric car ambition accounts for actual 2020 BEV sales, 2025 IHS Markit EU production forecast and the OEMs' 2030 public phase-out commitments.

**Strategy accounts for the battery manufacturing strategy, the charging infrastructure strategy and the use of BEV dedicated platforms.

Volvo Cars and Volkswagen Group (VW) both top the ranking and are - based on current plans - expected to be the European leaders of this transition. While Volvo committed to become a fully electric car company by 2030, VW is most advanced in the industrial transition (e.g. batteries and dedicated BEV platforms) despite a more modest BEV sales target of 60% for the group in 2030. Many carmakers such as Renault, Hyundai and Ford are in the middle with either ambitious commitments but not robust plans, or inadequate ambition on BEV technology altogether. Those that are heavily relying on hybrids

¹ Tesla is excluded as they are a manufacturer of 100% electric vehicles already. They would top the ranking if they were included.

even in 2030, such as Daimler and BMW, have a low score. Toyota comes last and, having bet on hybrid solutions for too long, is now a serious laggard in the electrification revolution that is underway.

To understand the role of PHEVs in the transition to fully electric cars, T&E has analysed their technical specifications as forecasted by IHS Markit. Despite PHEVs gradually adopting slightly larger batteries, the analysis shows that PHEVs produced in the next decade are not expected to be designed as credible zero emission-capable vehicles with limited zero emission range and weak electric motor power, thus not being able to achieve meaningful CO₂ saving in the real world. This is why carmakers that will heavily rely on them in the 2020s such as BMW and Daimler have low ranking. PHEVs are expected to remain what they are today: ‘fake electrics’ used as a compliance tool to meet CO₂ targets more easily. The upcoming review should remove all the generous credits given to PHEVs no later than 2030.

Although the production plans show encouraging trends towards faster electrification, the end result is still very uncertain without strong political support. In the best case scenario (with carmakers delivering on production plans and voluntary commitments), the estimated BEV sales would be around 26% in 2025, 38% in 2027 and 57% in 2030. While this is a step in the right direction, this is still 10% percentage points short of a Green Deal compliant trajectory that requires no less than 67% BEV by then. According to the plans uncovered in this report, the EU could achieve a 30-35% CO₂ reduction from new cars in 2025, around 50% in 2027 and 65-70% in 2030, which is close to two times more ambitious than the current EU targets and shows where the EU benchmark can be set.

Crucially, volume has been king in the automotive industry since the days of Henry Ford. Higher car CO₂ targets in the 2020s will push carmakers to mass produce electric cars early, which is essential to bring down the costs of BEVs and democratise the technology. Failing to increase car CO₂ targets in the mid 2020s means that none of the production plans highlighted in this report can be taken for granted or reach the market at affordable prices. There would be no guarantees or backstop to ensure adequate investments take place on time, also to support the entire ecosystem of battery, electronics and charging business to ramp up. (As a reminder, the car industry failed to deliver on its original 1998 voluntary CO₂ commitment to cut CO₂ from new cars to 140 g/km by 2008, which is why we have the mandatory car CO₂ standards today.) A higher 2025 standard and an additional target of at least 40% in 2027 are needed to guarantee the car industry delivers on time and to democratise electric cars in the 2020s.

Moreover, solely increasing the 2030 target to 50% would delay or even derail the BEV transition. The 50% target falls significantly short of what is needed: it would bring only 38% BEVs compared to 67% in the Green Deal compliant trajectory. In addition, the current regulatory design would in effect allow laggard carmakers to continue lagging behind even with a higher 2030 ambition. First, because of what’s known as “pooling”, laggards could simply buy credits from the carmakers with more ambitious plans to comply. For example, if Volkswagen delivers on its voluntary 60% BEV commitment, all other carmakers could sell only 30% BEV in 2030. Second, a weak 2030 CO₂ target could lead carmakers to divert from their high-BEV production plans (which are zero emission) towards suboptimal PHEV strategies (low emission) thus delaying the introduction of more affordable and cleaner full electric

cars. At least a 65% CO₂ reduction is needed - alongside tightening the current regulatory loopholes - for a credible 2030 regulation.

Building a future-proof battery electric industry is key to ensuring the EU economic sovereignty and avoiding being outpaced by foreign competitors. It is also a strategic opportunity to support the development of new industrial clusters such as battery manufacturing by guaranteeing them a certain commercial offtake from the domestic electric car market. As the EU is approaching a tipping point in its fight against climate change, decisive environmental policies cannot rely exclusively on voluntary commitments from businesses. Strong guarantees are required to achieve ambitious CO₂ reduction in line with the EU's climate ambition.

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Introduction

With more than 1 million plug-in electric vehicles sold in the European Union (EU27) in 2020, the electric car market is booming. Despite the COVID-19 pandemic and its major economic and industrial implications, electric vehicles (plug-in electric cars including battery electric and plug-in hybrid, later referred to as EV or plug-in vehicles) sales surged from 3.0% in 2019 to 10.5% in 2020 [1]. This growth is driven by carmakers' (OEMs) efforts to comply with the new European car CO₂ standards applicable from 2020.

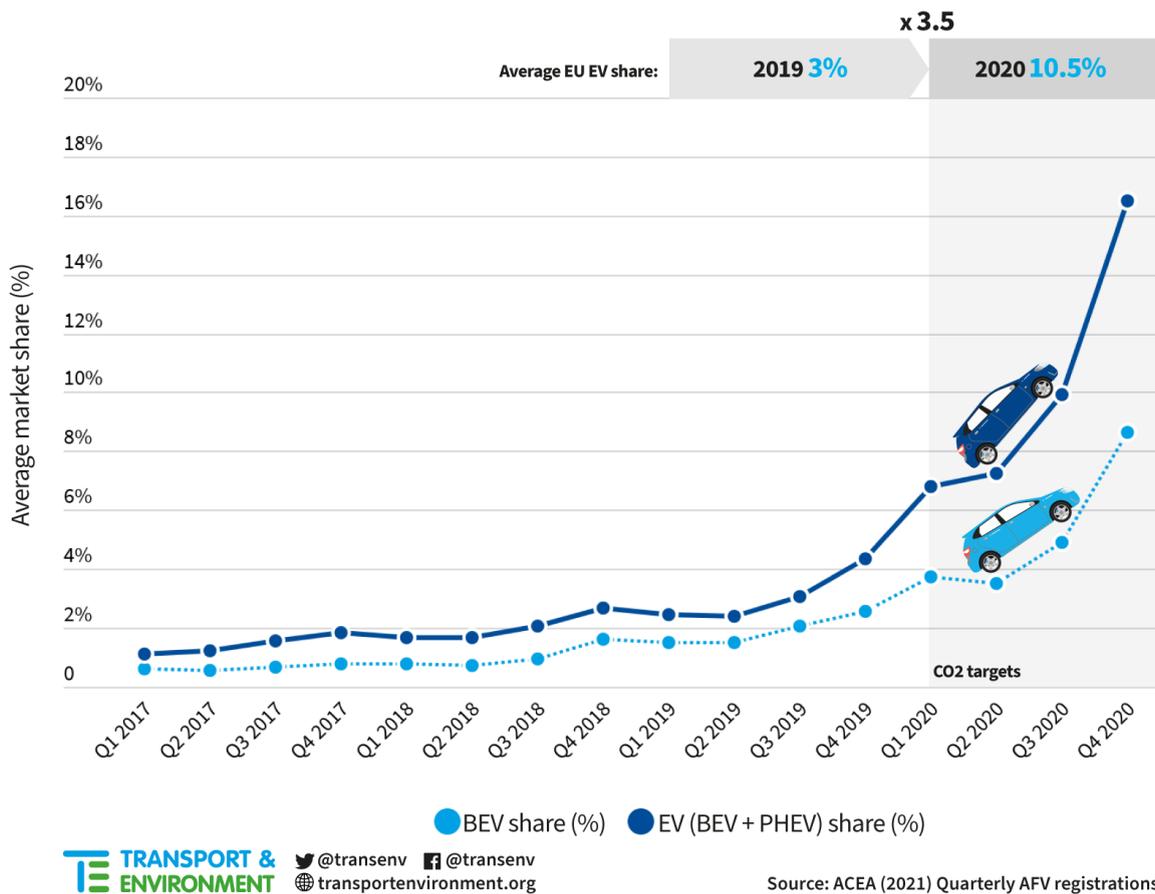


Figure 1: BEV and EV share of sales in the EU

In 2020, the EU27 EV market was made of more than half Battery-Electric Vehicles (BEVs, 51.5%) and 48.5% Plug-in Hybrid Vehicles (PHEVs). The EV market share is particularly high in Nordic countries with up to 32% BEV in Sweden, while Germany and France are the largest markets in EV sales volume with 395,000 and 186,000 units. In spite of lower volumes, Central and Eastern European countries are witnessing a strong growth rate with EV volumes increasing almost 8 fold in Slovenia from 2019 to 2020 and 4 times in Slovakia. Globally, Europe became the largest EV market in 2020 as its total sales volume surpassed the Chinese market by 2%. Market data from the first quarter of 2021 demonstrates a trend toward PHEVs as 6 out of 10 plug-ins sold in the EU were PHEVs.

The long-awaited 2020/21 CO₂ standards entered into force on January 1st 2020 to boost the EV transition. By giving a legal obligation to carmakers to lower the emissions of their new car fleets, the CO₂ standards are the main driver of the 2020 electric cars uptake and a wider industrial transformation. Nevertheless, the surging EV market masks many regulatory flaws and failures to cut emissions: carmakers are now pushing towards suboptimal plug-in hybrid technology, the vehicle mass increase favoured by the regulation could lead to a rise in sales of heavier and more polluting vehicles, and the pooling flexibility could allow some OEMs to rely on partners instead of developing and producing more EVs. The biggest risk is that the EV market could stagnate between 2022-2029 unless the current post-2020 standards are strengthened.

The aim of this report is to assess the expected speed of electrification over the next decade and how the CO₂ regulation could secure and strengthen this mobility transition. Section 1 looks into the EV production forecast in Europe from 2021 to 2033 and gives an overview of EU car production and technology trends. Then, Section 2 shows how the EV production is expected to be distributed among European countries. Section 3 assesses and ranks carmakers readiness with regards to the mobility transition by evaluating in detail their strategies. Finally, Section 4 presents the implications of carmakers electrification ambitions with regard to European car CO₂ regulation.

This paper does not aim to predict the future; rather it aims to give some insights on what can be expected from the EU vehicle market in the medium-term future based on the carmakers' production plans known to date. The purpose of this report is to analyse the impact of current industrial plans and CO₂ regulations on the European market - it should not be considered as a market forecast.

1. Car production in Europe: a shift to BEVs

This section presents an overview of the expected European car production in the next decade based on IHS Markit light vehicle production database from April 2021². This database includes the worldwide production forecast for all carmakers from 2021 to 2033. IHS Markit forecast is based on industrial insights and carmakers' announcements until early 2021, as well as an advanced analysis of regional economic and industrial conditions. Although any forecasting exercise cannot be considered as an exact and definitive prediction of the future vehicle production, this database gives a clear overview of the market trends in the coming years.

The IHS Markit database details the light duty vehicle production of each OEM nameplate version with information including vehicles, engines, e-motors and battery specifications. The production location is

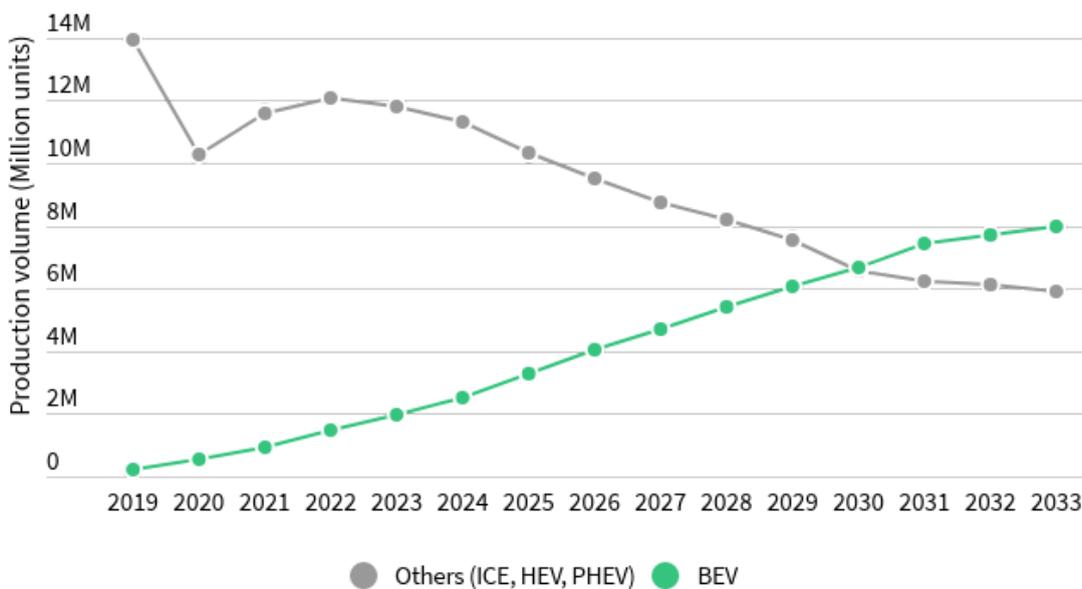
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given by countries, and T&E analysis focuses on the EU27 + UK, later designated as Europe. Data presented in this report includes only passenger cars.

As the market is currently facing fast changes, some of the latest OEM announcements might not be perfectly reflected in the database. For instance, the Renault brand recently announced that it would sell 90% fully electric and plug-in hybrid cars in 2030 [2] and this strategy is not converted yet in actual production plans in the IHS Markit forecast. Moreover, as the database considers production volume only, it does not include sales information accounting for imports and exports between different regions.

1.1. BEVs will dominate EU production from 2030

The number of fully electric cars (BEV) produced in the EU27 is expected to grow through the 2020s and account for slightly more than half of the total car production in 2030. From around 530,000 BEV produced in 2020, their production would reach 3.3 million in 2025 (24% of the production mix) and 6.7 million in 2030 (50%)³. At the same time, internal combustion engine vehicles (shortened as ICEs, include mild hybrids), full hybrids (HEVs) and PHEVs are expected to decline from 14 million cars produced in 2019 to 6.6 million in 2030. As shown in Section 1.2.1 below, the production of PHEV is also expected to rise in the first part of the decade but should peak in the EU27 + UK at 12% in 2025.



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 2: BEV and other types (ICE, HEV, PHEV) production in the EU27

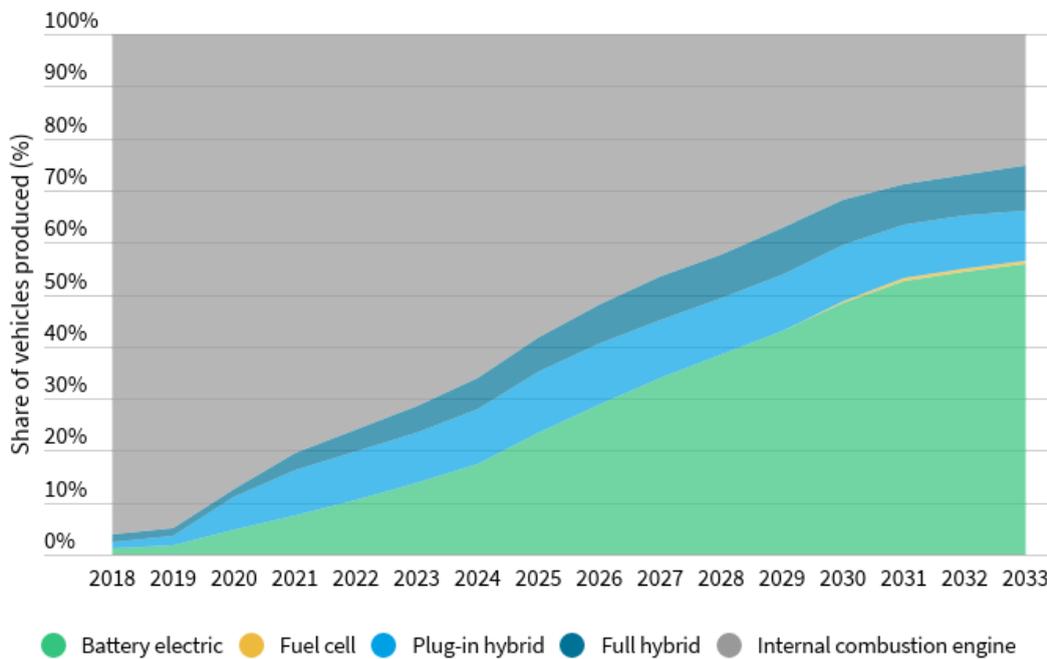
This trend clearly shows that BEV technology is widely endorsed by car manufacturers in Europe, and is bound to become the dominant technology in less than a decade.

³ If considering the EU27 + UK, the BEV share in the production mix reaches 48% in 2030.

1.2. Other fuel types will play a limited role

The 2020s will be a decade of major changes for car production in Europe. From a market dominated by ICEs accounting for 87% of 2020 production, and BEVs still in minority, the roles will be reversed by 2030, see Figure 3. In this context, other technologies (listed in this section) will coexist in 2030 with BEVs but they will play a limited role.

Plug-in vehicles (BEV and PHEV) are expected to play a significant role in the future. From a combined share of 11.2% in the EU27 + UK production in 2020, EV production is expected to ramp up quickly: the 2025 average production mix is expected to include 23% BEV and 12% PHEV, then BEV would reach 34% and PHEV 11% in 2027. Finally, the 2030 European production is expected to be composed of 48% BEV and 11% PHEV.



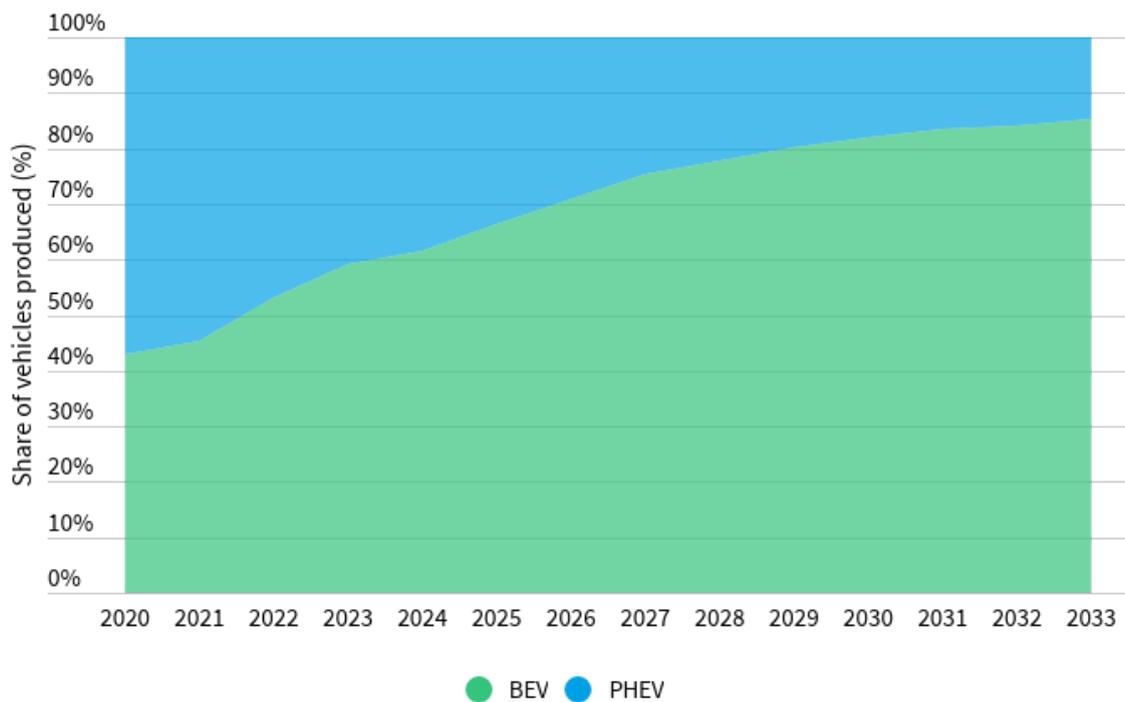
Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 3: EU27 + UK car production share per type

1.2.1 Plug-in hybrid vehicles

On the current projections, the number of PHEVs⁴ produced in Europe is expected to grow from 750,000 units in 2020 (6%) and peak at 1.7 million units in 2025 (12%). In 2030, PHEVs would still represent 11% of the cars produced with 1.5 million units. Compared to all plug-in cars (both BEVs and PHEVs), the share of PHEV is expected to decrease from 57% of plug-in cars produced in 2020 to 34% in 2025 and only 18% in 2030, see Figure 4.

⁴ PHEVs are hybrid vehicles that have both an ICE and an electric motor and can be plugged to recharge their batteries.



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 4: Distribution of BEV and PHEV in plug-in car production in the EU27 + UK

As detailed in Section 3.2, the carmakers with the highest PHEV share in their production mix would be BMW with 27% of its total car production in 2030 and Daimler with 22%, while the EU average would be at 11%. And the ratio of PHEV over the total plug-in production is also confirming the preference of these carmakers for PHEVs: Daimler is expected to have 40% PHEV in its EU plug-in production and BMW 37%. On the other hand, some carmakers are expected to rely far less on PHEVs: Toyota is expected to have only 7% PHEV in its 2030 plug-in production and the Volkswagen Group (VW) 10%.

From a technology point of view, there are several reasons why PHEVs are not expected to play a larger role in the next decade:

- First, PHEVs are expected to be used mainly in segments with large vehicles as the technology requires to fit both ICE and electric systems (including the electric drivetrain and batteries). For instance, PHEVs would only account for 1% of the cars produced in segment B in 2030, whereas they are expected to represent 13% in segment D and 23% in segment E.
- Secondly, the power of PHEV electric motors is in fact closer to the one of regular hybrid technologies than of fully electric vehicles (refer to info box in Section 3.5). This means that PHEVs' weak e-power and relatively low battery capacity would not enable them to drive in zero emission mode for a long time without starting the combustion engine.
- Third, the use cases of PHEV are expected to remain limited as the BEV range is increasing. Today, PHEVs are advertised as a solution to reduce range anxiety, but the average battery capacity of BEVs is expected to grow by 32% over the next decade - from 54 kWh in 2020 to reach 72kWh in 2030. Moreover, BEV efficiency is also expected to improve as new battery technology energy density is growing (BNEF assessed that NMC 9.5.5 would result in a 23% increase in energy density [3]). Consequently, as BEVs will allow driving a longer distance without charging,

drivers' range anxiety is expected to fade away at the expense of PHEVs and the roll-out of the charging infrastructure should reinforce this trend.

- Finally, as BEVs would reach price parity with ICEs in the mid 2020s, PHEV costs, that are higher than ICE due to the complexity of the hybrid architecture, are not expected to benefit from the same reduction as for BEVs.

Therefore, according to current carmakers production plans, as BEV production is ramping up and the transition well on its way, PHEVs are being gradually abandoned in favour of fully electric cars. Nevertheless, as PHEV production is sensitive to policy changes, there is a risk that OEMs ramp up their PHEV production plans if future EU Car CO₂ targets or national taxes reward them generously or are just too weak.

Why are PHEVs a problem?

PHEVs on sale today mostly have very limited zero emission driving ranges and are fitted with electric motors not capable of delivering the necessary power to drive in zero emission under all conditions. These cars are closer to conventional internal combustion engines cars than BEVs and are sold by carmakers as a compliance strategy to easily meet their CO₂ targets.

Tests on three popular models conducted by Emissions Analytics for T&E [\[4\]](#) in 2020 showed that, when not charged, PHEVs are not any better and sometimes worse than conventional ICE's with CO₂ emissions up to eight times higher than the official figures. When the engine is used to both power the car and charge the hybrid battery for later use, as much as 12 times the official CO₂ value can be emitted. Their zero emission range, which is key to delivering substantial CO₂ reductions on the road, can also decrease drastically, due to low powered e-motors fitted, by up to 76% when tested with higher load, during motorway driving or dynamic driving conditions. This means that it can be difficult to drive these vehicles without the internal combustion engine even when starting the journey with a fully charged battery.

Moreover, as shown by the ICCT [\[5\]](#), PHEV real world utility factors (UF) i.e. the electric share of the total distance driven, are about half of those assumed for calculating official PHEV CO₂ figures. The private car official average UF is 69% compared to 37% for real-world driving. The gap for company cars, which account for 74%⁵ of PHEV sales in the EU, is even wider with 63% officially but just 20% for real-world driving. This means that average real world PHEV emissions are in reality two to four times higher (for private and company cars respectively) than official figures suggest.

These findings highlight that PHEVs are mostly driven using the internal combustion engine and fail to provide the real world emissions reductions that are promoted by and benefit OEMs. Carmakers are building suboptimal PHEVs, with limited e-power and battery capacity to benefit from regulatory incentives for low emission vehicles while failing to deliver the expected CO₂ reductions on the road. PHEV e-power and battery capacity is further analysed in Section 3.5.

⁵ Author's calculations based on Dataforce. (2021). New passenger car registrations.

1.2.2 Full hybrid vehicles

Full hybrid vehicles (HEVs) refer to ICE vehicles that can use an electric motor to slightly improve their fuel efficiency⁶ but cannot be externally charged. Production of HEVs is expected to increase from 156,000 units in 2020 (or 7% of EU production) to 1.3 million units in 2030 (9%).

In 2030, the average power of the electric motor of HEVs is less than half of BEVs (43%) and the battery is only 1.8 kWh on average - or around 40 times less than the average BEV battery in 2030. Despite sometimes being considered as “electrified” by some carmakers, HEVs are technically limited in their design and cannot be considered as a zero or low emission solution.

In 2030, HEVs are expected to be produced mainly by 4 carmakers: first Renault, which would produce 42% of all EU HEVs in 2030, then VW with 29%, Toyota⁷ 19% and Jaguar Land Rover (JLR) 10%.

1.2.3 Internal combustion engine cars

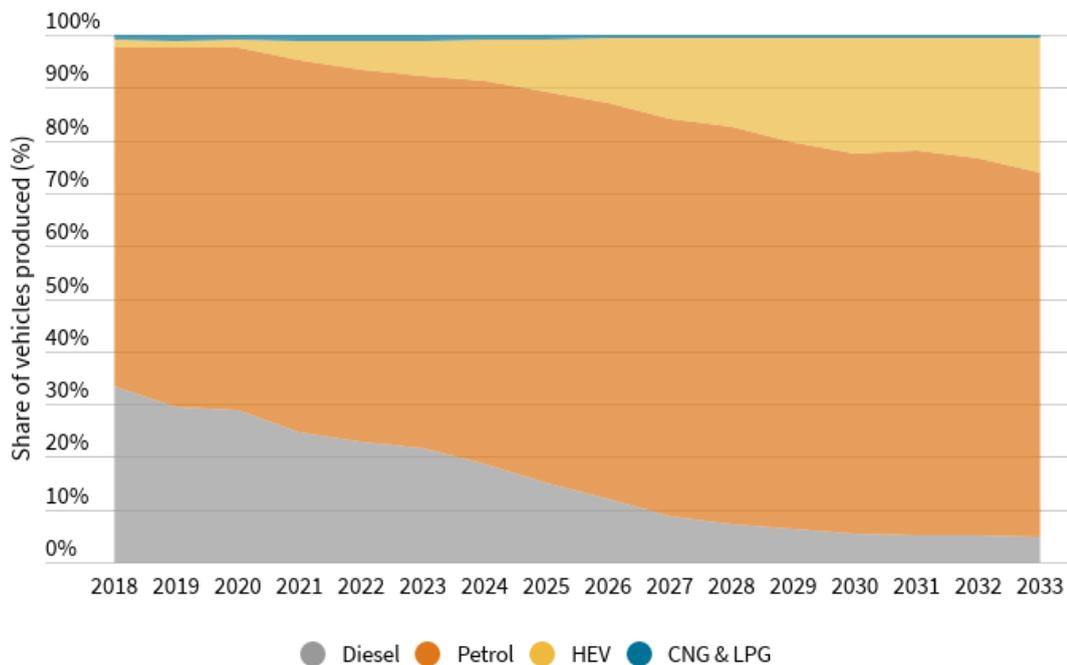
Here, ICE types include mild hybrids, pure ICEs without hybridisation (both diesel and petrol) and other fuel types such as CNG and LPG. Mild hybrids are specific hybrid cars that cannot drive in electric mode and provide very limited fuel savings (around 9% [6]). Their reliance on the combustion engine makes them a poor technical solution for emission reduction and they are considered here as conventional ICEs.

ICEs are expected to face a 56% reduction in production volume between 2020 and 2030 and would descend to 4.5 million units. Mild hybrids would amount to 93% of ICEs in 2030 while ICEs without hybridisation would decline down to 7%.

Figure 5 shows the share of the different fuel types among all non plug-in vehicles (full hybrids, CNG & LPG, ICEs). While the share of petrol cars is expected to remain broadly constant, diesel cars are expected to fall from 30% of the non plug-in production at the start of the decade to only 5% in 2030. Half of the cars still using diesel engines in 2030 will be in segment D while the last diesel cars in segment B are expected to be produced in 2026.

⁶ HEVs can drive in electric mode but only on quite short distances and usually at low and moderate speed due to the relatively low power of the electric motor and their small battery (1.8 kWh average in 2030).

⁷ Toyota is known to rely significantly on the Full Hybrid technology, and the Japanese carmaker is importing part of the vehicles it sells in Europe, therefore it might account for a more significant part of Full Hybrid 2030 EU market share.



HEV refers to full hybrid vehicles

Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 5: non plug-in vehicles production in the EU27+UK

Alternative technologies such as compressed natural gas (CNG) and liquefied petroleum gas (LPG) are expected to play a negligible role in 2030 with 36,000 units (0.8% of ICEs produced) or just 0.25% of the total number of cars produced in the EU27 + UK. CNG production would shrink in 2030 and reach only 5,000 units produced by VW. Renault would be the only carmaker still using LPG in passenger cars in Europe: the French OEM is expected to produce 31,000 LPG cars in 2030.

1.2.4 Fuel cell electric vehicles

Despite being a zero emission technology, fuel cell electric vehicles (FCEV) production should barely reach 40,000 units in 2030 in Europe, amounting to 0.28% of the total number of cars produced. According to IHS Markit forecast, FCEVs would be produced by VW Group, Daimler, JLR and BMW⁸. Nevertheless, recent public declarations from Daimler [7] hinted that they were stopping the development of FCEVs and VW [8] precisely said that it would not even consider the solution in ten years. Therefore, IHS Markit forecast could be overly optimistic: without VW and Daimler plans, the FCEV EU production would be as low as 9,500 units.

⁸ Some international OEMs that are already committed to the production of Fuel Cell vehicles, such as Toyota or Hyundai, are expected to keep their manufacturing capacity out of Europe. In that case, the sales offering of FCEVs could largely exceed the forecasted production in the EU as some OEMs would import those vehicles, at the expense of the European industry.

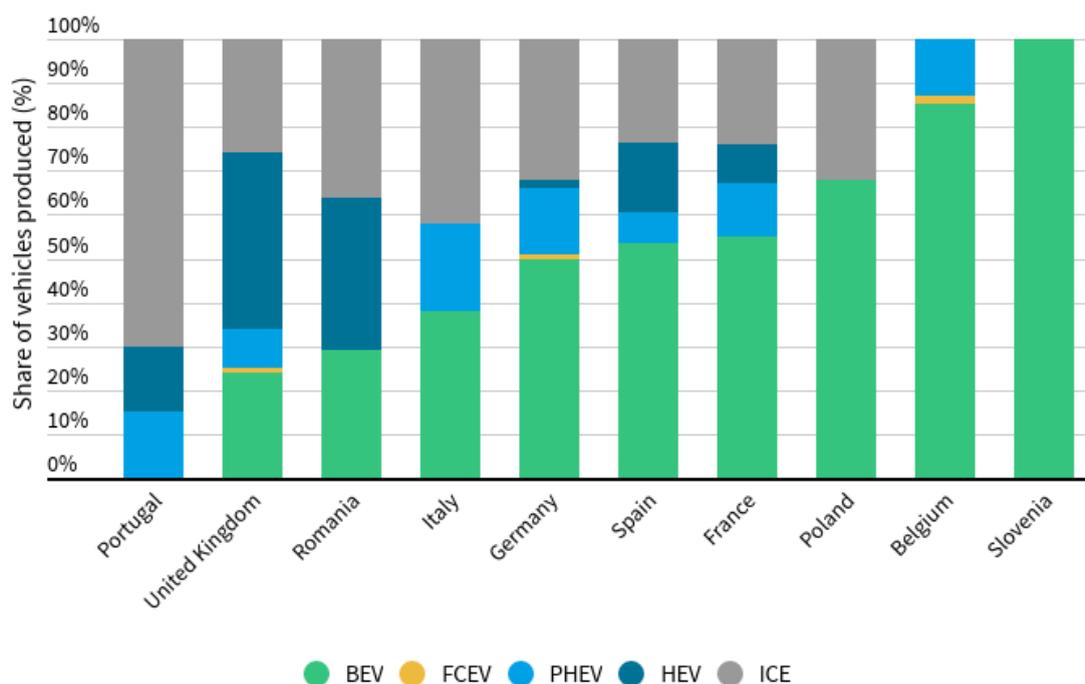
High costs, lack of technical maturity as well as the challenge of green hydrogen production and the roll out of hydrogen infrastructure are all likely to be major obstacles to the growth of FCEVs. On the basis of this recent industry forecast, it is clear that FCEVs will not play a big role in the future of passenger cars in Europe, and that BEVs are the main future-proof and credible zero emission solution in this road segment.

2. Electric car production per country

Electric car production surges and the decline of ICE production is seen in almost all European countries in the 2020s. Overall, the production of electric cars is expected to nearly offset the decline of ICE production but not all countries are expected to shift to BEV production at the same speed. Germany, Spain and France are expected to be the largest producers of BEVs in 2030, while Slovenia, Slovakia and the Czech Republic will have the largest production per capita.

2.1 Fuel type overview across European countries

The breakdown of the fuel type production split across some European countries gives an overview of the status of the EV transition in 2030 (as shown Figure 6).



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 6: Examples⁹ of fuel type production share expected in 2030 in some European countries

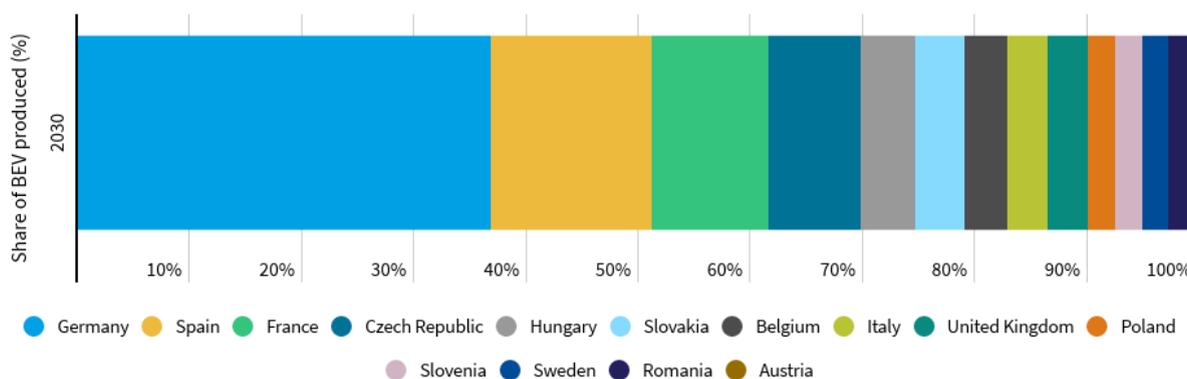
⁹ The contractual agreement with IHS Markit does not allow T&E to disclose the vehicle production mix for all EU countries. Examples are provided for ten countries: the six most populated European countries (Germany, Spain, France, Italy, the UK and Poland), as well as two additional countries with low BEV share of production (Portugal and Romania) and two with high BEV share of production (Belgium and Slovenia).

Slovenia is the first country expected to switch to a 100% BEV production with Renault and Nissan planning to produce their smaller B-segment BEVs in the country. Belgium should achieve an 86% BEV production thanks to Volvo and VW production plans. Countries with major car markets are expected to have BEV production share close to the EU average: France is projected to reach 55% BEV in 2030, Spain 54% and Germany 50%, but Italy is limited to 38%.

On the other hand, the production shift to BEVs is projected to be lagging behind in several countries: in Portugal, VW and Toyota are still expected to produce only ICE versions of their cars. In the UK, BEVs would not reach more than 25% of the production in 2030 as JLR, Nissan or Toyota are expected to produce mainly ICEs and HEVs. Finally, Romania is expected to reach 29% BEV thanks to Ford, while the Romanian Renault Dacia brand is not planning to produce any electric version in the country focusing its BEV production in China instead.

2.2 Battery electric car production breakdown

In 2030, Germany is expected to be the European country with the largest production volume of battery electric cars, with more than 2.5 million units, accounting for 37% of the EU27 + UK BEV production (see Figure 7). The second largest BEV producer is projected to be Spain with nearly 1 million cars (14% of EU production), then France with 10% and the Czech Republic with 8%.



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 7: BEV production share across European countries in 2030

In order to better understand the relative impact of EV production on countries' economies, Figure 8 compares the number of vehicles produced per capita so that the differences in workforce size are better reflected. Eastern countries such as Slovenia, Slovakia, the Czech Republic and Hungary would benefit the most from the EV transition as they have the highest number of BEVs produced per 1,000 inhabitants, while larger countries such as the UK, Italy or Poland are not expected to have a high BEV production per capita.

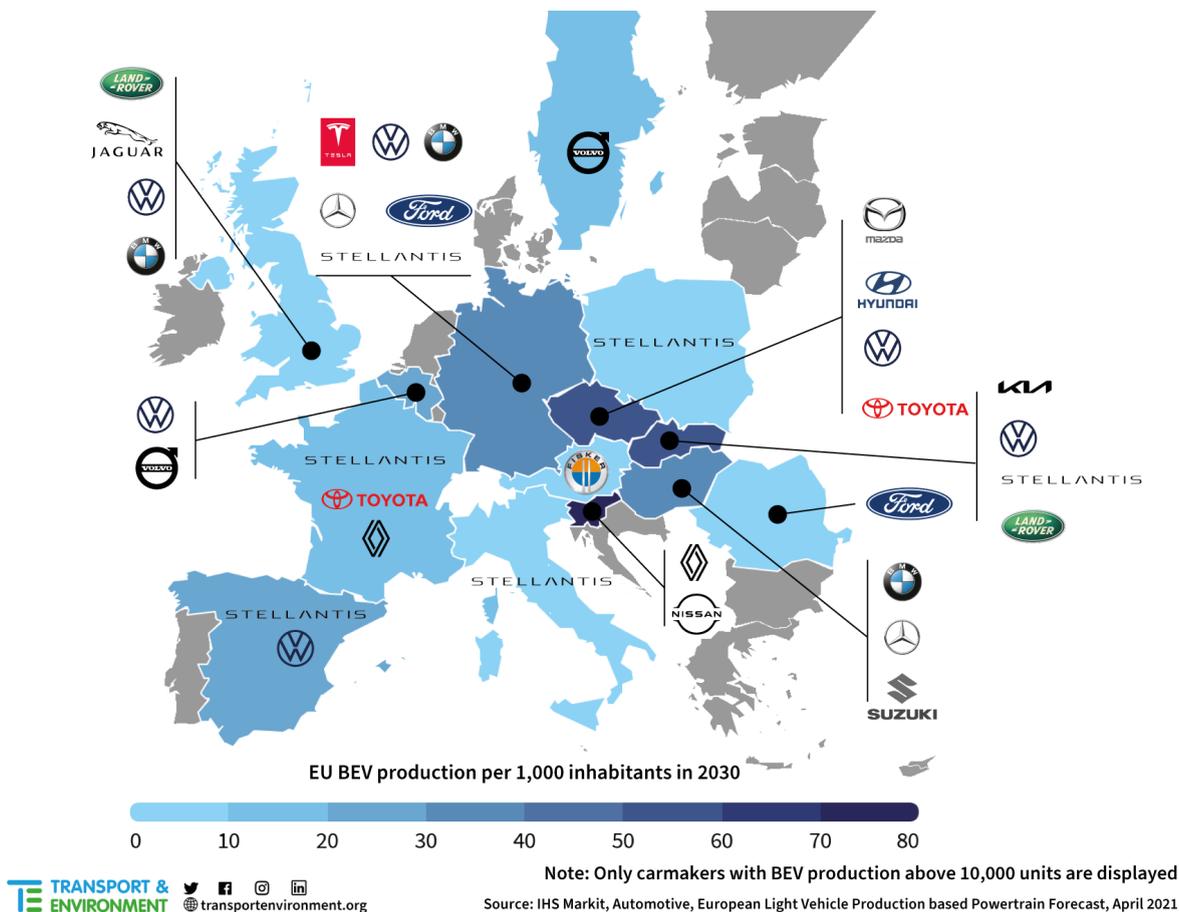


Figure 8: Europe’s BEV production per 1,000 inhabitants in 2030

Figure 8 also shows the location of the OEM plants with BEV production projected to be over 10,000 units in 2030. Germany has the highest concentration of OEMs with 6 electric car makers, then both the Czech Republic and Slovakia have 4 OEMs producing within their territory. Including small volumes BEV production, VW has the most widespread distribution with plants located in 7 countries across Europe, Stellantis in 6 countries, BMW in 4 countries and Daimler in 3 countries. This shows that OEM production plants are well distributed across Europe and that most countries will benefit from industrial opportunities.

2.3 Evolution of overall EU car production between 2019 and 2030

This section looks into the evolution of vehicle type produced in European countries between 2019 and 2030 to understand to what extent the decline in ICE production is compensated by the rise of BEV production in each country.

In Figure 9, ICE production accounts for the production of all ICEs including hybrid vehicles (PHEV and HEV) while zero emissions vehicles (ZEV) accounts for BEV and FCEV. The green bar depicts the growth in ZEV production between 2019 and 2030 while the grey bar shows the reduction in ICE production. For

each country, the variation is based on the vehicle production per capita which is more representative of the importance of vehicle manufacturing in that country (left axis). On the right axis, the variation in for the overall vehicle production is shown as the percentage difference between 2030 and 2019 total car production (blue line). This relative variation shows the resulting impact of change in ZEV and ICE production on the total vehicle production of each country: the variation is positive when ZEV growth offset the ICE reduction.

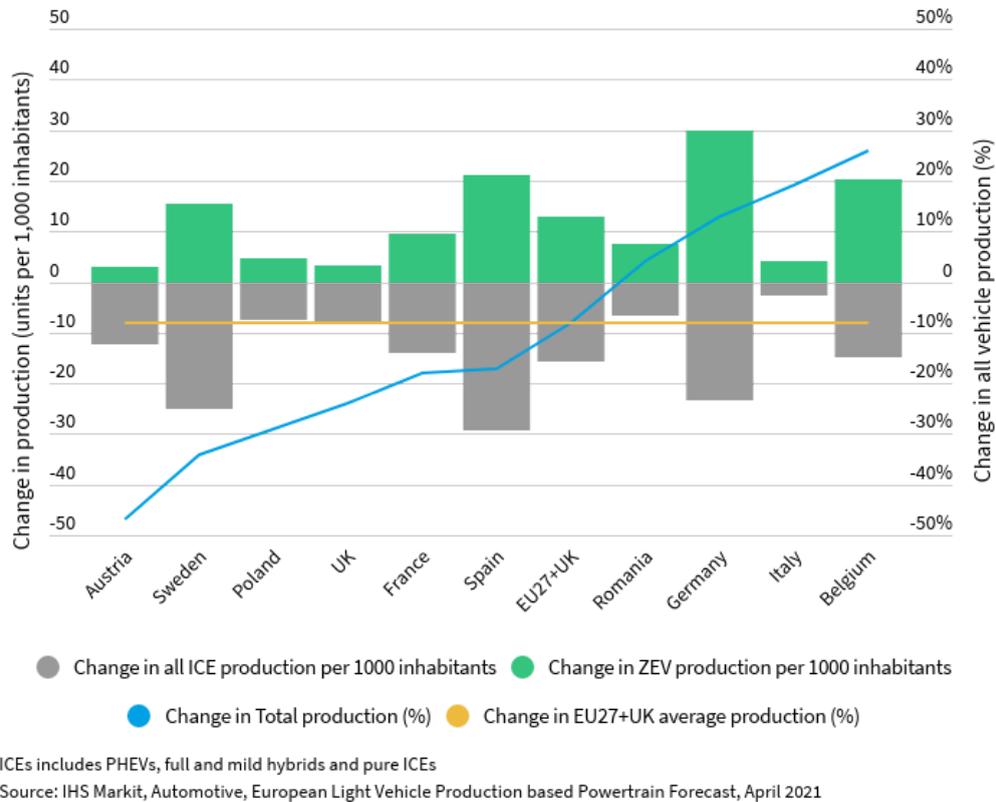


Figure 9: Examples¹⁰ of evolution of vehicle production per 1,000 inhabitants from 2019 to 2030

According to IHS Markit forecast, total passenger vehicle production in 2030 would be 8% below the pre-Covid 2019 production levels. There are two possible explanations for this decreasing trend (not mutually exclusive). Firstly, after the major drop in car production in 2020 due to the COVID-19 pandemic (-24% compared to 2019), car production is not expected to fully recover due to its long lasting economic impact. Secondly, growing concerns about climate change, air quality, city congestion and livelihood across Europe as well as move away from private car ownership have also been expected to lead to a peak in car production and sales. Indeed, national and local authorities are increasingly promoting new policies in favour of public transportation, car sharing and modal shift. Despite this slight decrease in the total car production, in most cases, the drop of ICE vehicles production will be nearly entirely offset by the increase of fully electric cars production.

¹⁰ The contractual agreement with IHS Markit does not allow T&E to disclose the vehicle production mix for all EU countries. Examples are provided for ten countries: the six most populated European countries (Germany, Spain, France, Italy, the UK and Poland), as well as two additional countries with a high production volume decrease (Austria and Sweden) and two with a high production increase (Belgium and Romania).

Several countries - notably Belgium, Italy, Germany and Romania - are expected to be the main beneficiaries of the EV transition with an increase in BEV production larger than the ICE production decline. From 2019 to 2030, Belgium will increase its total car production by 26%, Italy by 19%, Germany by 13% while Romania expects a 4% increase.

Slovakia, the Czech Republic and Hungary are expected to face a decrease in production in line with the average EU decrease (around 8%), while France, Spain and Slovenia may face a higher drop (down to 17%).

Finally, the most impacted countries are the following: the UK's total production is projected to decrease by 24%, Poland's by 29%, Sweden's by 34% and Austria's by 47%. Portugal, with a 51% decrease in production, will be particularly affected as well as no carmakers seem to plan any BEV production in 2030. Finally, the data shows that carmakers will stop car production in Finland and the Netherlands by 2030¹¹ altogether.

For total production volumes, Germany is expected to strengthen its position as the largest European producer while Spain and France are ranking in second and third position despite a moderate decrease of their production. The decrease of car production in the UK would rank it at the same level as Slovakia in 2030. Hungary is expected to be overtaken by Romania while Belgium is expected to overtake both Poland and Sweden.

2.4 Zoom on the six largest countries

This section focuses on the state of BEV production in the six largest countries by population. Dedicated infographics for each of these countries can be found in Annex 6.1.

In **Germany**, the total car production is expected to see a 13% increase and exceed 5 million units. The number of BEVs produced rises steadily to reach half of the total production. But ICEs will remain the second most common type produced with the third of the country's production. With 31 BEVs produced per thousand inhabitants in 2030, Germany is among the countries with a high BEV production per capita. Around half of the BEV production is expected to be from VW Group while BMW and Tesla would be the second and third BEV producers in the country. The global increase of the German production is partly supported by the addition of Tesla production that would amount to 60% of the production volume increase.

Spain is expected to remain the second largest car producer with 1.8 million units and nearly 1 million BEVs in 2030. BEVs are projected to exceed half of the production but ICEs and HEVs are still expected to be produced in high volume in the country. Carmakers are expected to produce 21 BEVs per thousand inhabitants making Spain a country with medium BEV production per capita. The drop of ICE production

¹¹ BMW is expected to stop Mini production in the Netherlands in 2023 and switch its production to Germany and the UK. Daimler might stop the production of A-Class and GLC models in Finland in 2022 to produce them in Germany and Hungary.

is not going to be fully offset by the rise of BEVs as the country's total production will decrease by 17%. Spain is actually expected to be the country with the highest decrease in its total production volume with around 400,000 fewer units in 2030. Two BEV carmakers will be implanted in Spain: VW and Stellantis are expected to equally share the BEV production. Moreover, the current production plan for Renault in Spain does not include any BEV production, but the actual implementation of Renault brand latest commitments (90% BEV and PHEV in 2030) might change those plans.

In **France**, the total forecasted production decreases to around 1.3 million in 2030 (-18%), but France should remain the third highest car producer in terms of total volume. With 11 BEVs produced per 1,000 inhabitants in 2030, France has a rather low BEV production per capita even if BEVs exceed half of its production. Renault, Stellantis and Toyota are the three OEMs expected to produce BEVs in France. Renault is expected to produce slightly less than half of the BEV production and Stellantis and Toyota would be in second and third position. ICEs are still expected to account for the fourth of the production while PHEVs and HEVs complete the production mix. Only Renault is expected to switch its production to 100% BEV in France. France is expected to see a small temporary decline in BEV production in 2024 as the Smart BEV production is expected to move to China and Ineos takes over the plant for the production of its ICE Grenadier model.

Italy is expected to see a 19% increase in its total car production and would exceed 600,000 units in 2030. Nevertheless, the share of BEVs in the Italian production mix is expected to be slightly lower than ICEs as they would account for more than 40% of the production. With around 20% of the total production, PHEV is the third technology used in Italy. Four BEVs are expected to be produced per thousand inhabitants in 2030, ranking Italy as one of the countries with the lowest level of BEV production per capita. Nearly all BEVs are expected to be produced by Stellantis but the OEM is still expected to produce a high amount of ICEs and PHEVs in the country.

In the **UK**, car production is expected to slow down: around 1 million cars will be produced in 2030 (-24% compared to 2019). The share of BEVs is expected to stay relatively low with only the fourth¹² of the total in 2030. This makes the UK the country with the lowest BEV production per capita with only 3.6 BEV produced per thousand inhabitants. But ICEs would not be the main technology used: they amount to the fourth of the production whereas HEVs are expected to be as high as 40%. Regarding BEVs, JLR is expected to produce around three fourths of the UK-produced BEVs in 2030, followed by BMW. The HEV trend is mainly driven by Nissan Qashqai production (half of HEVs)¹³ and - to a lesser extent - by both JLR and Toyota. Nissan is projected to stop producing BEV in the UK as the Leaf model production could be stopped in 2024.

Poland car production depends on Stellantis, the only carmaker active in Poland. The country is expected to see BEV production increasing up to 2024 before stagnating and starting to rise significantly in 2030 and then meeting 100% BEV production in 2031. But, with only 5 BEVs produced by thousand inhabitants in 2030, Poland is among the countries with low BEV production per capita.

¹² The UK BEV production could be higher than expected, indeed BMW's Mini brand is aiming to become an all-electric brand [9] whereas some ICEs are still included in its current production plans.

¹³ Despite using an ICE to generate electricity for the e-motor (hybrid series configuration), the Nissan Qashqai is not expected to have a plug to recharge its battery.

3. Carmakers' readiness facing the EV transition

3.1. T&E EV Readiness Index

All major carmakers are making public announcements with regards to their mobility ambitions. The aim of this section is to go beyond these voluntary targets and claims to understand really how ambitious and committed that carmakers are. To this end and to compare how OEMs are prepared for this mobility transition, T&E designed an EV Readiness Index.

T&E's index focuses on traditional ICE carmakers and their transition from ICE to BEV. The index assesses and compares 10 major carmakers in Europe, namely, BMW, Daimler, Ford, Hyundai-Kia, JLR, Renault Group, Stellantis, Toyota, Volvo Cars and VW Group. Tesla is excluded from the list as they only produce BEVs and do not need to transition, however T&E did rank them for comparative purposes - they would top the ranking by a margin.

The EV Readiness Index is designed by taking into account both quantitative data from OEMs production and their publicly announced sales targets, as well as a comprehensive assessment of OEM industrial strategies to get them to their targets, notably EV architecture (e.g. platforms), technology mix, actions in battery manufacturing and supply chains and charging infrastructure.

It aims to give a wider picture and assess the coherence of the public announcements regarding the industrial transition with the production plans and sales targets. Indeed, to be considered as ready to face the EV transition, a carmaker needs to have ambitious production plans in order to reach a high share of BEVs sold across the decade and to support the wide industrial ecosystem that is key to the adoption of the BEV technology. Current action and production plans to 2025 is more certain than longer term 2030 announcements, so the ranking allocates points for early action such as BEV sales in 2020 and BEV platforms plans in 2025.

This index is based on 100 points divided into 2 main categories:

1. The **BEV ambition** (/50) criteria is a rating of the BEV sales ambition through the decade. It includes the share of fully electric cars sold in 2020, the share of BEVs in the EU production mix in 2025 as well as OEM public announcements for the 2030 BEV sales (or IHS Markit production share when no clear BEV commitment was made). Long term ambition (2030) is scored with the same amount of points as short term ambition (2020 and 2025 combined). Additional bonus points could be given for carmakers producing well designed PHEVs, but the analysis presented in Section 3.5 suggests that no carmaker is actually planning any such PHEVs in 2030.
2. The **Industrial Strategy** (/50) is a qualitative rating of OEM strategies including announcements on different fields such as a European battery manufacturing plans (out of 20), the use of a BEV dedicated platform (out of 20) or the support of deployment of the EV charging infrastructure (out of 10).

Table 1 below summarises the results and the ranking of the 10 main conventional OEMs included in the scope of this analysis. A brief explanation is included below while the wide analysis and research is presented in the following sections (3.2 to 3.5) and detailed in Annex 6.5.

Table 1: OEMs ranking according to T&E EV Readiness Index

Carmakers	Electric car ambition* (/50)	Strategy** (/50)	Overall readiness (/100)	
	41	29	70	EV readiness: Lowest to highest    
	25	45	70	
	31	26	57	
	27	25	52	
	28	19	47	
STELLANTIS	22	24	46	
DAIMLER	17	29	46	
	23	21	44	
	26	16	42	
	14	21	35	

*Electric car ambition accounts for actual 2020 BEV sales, 2025 IHS Markit EU production forecast and the OEMs' 2030 public phase-out commitments.

**Strategy accounts for the battery manufacturing strategy, the charging infrastructure strategy and the use of BEV dedicated platforms.

Based on T&E readiness index, **Volvo Cars** appears to be the OEM with the most coherent and appropriate overall EV strategy with 70 points. Indeed, the Swedish OEM is committed to become a fully electric car company by 2030 [10]. Very implicated in the ethical sourcing of battery materials and in the circular economy, Volvo is also expected to move to BEV dedicated platforms in the second half of the decade [11].

Volkswagen Group shares leadership with Volvo Cars and is ranked second with equally 70 points. Despite a more modest BEV sales target of only 60% fully electric in 2030 [12] (hence second), the German group has the best industrial plan. It is committed to the industrial transition with 6 “gigafactories”¹⁴ planned [13] including both in-house production and partnerships, the design and deployment of two dedicated BEV platforms (the MEB early 2020, Modular Electric Drive toolkit [14], and PPE, Premium Platform Electric [15], from 2022) and investment in energy and charging solutions through its subsidiary Elli [16].

¹⁴ Battery cell plants with a production capacity of several gigawatt hours of cells each year.

In third position, **Renault Group** gets 57 points thanks to an early start for BEV sales and an ambitious 90% electrified vehicles planned for its Renault brand in 2030 including mostly BEVs as well as PHEVs [2]. Renault is expected to benefit from the partnership of the Renault-Nissan-Mitsubishi alliance with Envision AESC to source batteries from Sunderland [17] and Douai [18] and is highly active in battery circularity with the Re-factory project for its Flins plant [19]. **Hyundai-Kia** is ranked in fourth position with 52 points. The Korean Group did not communicate a 2030 BEV sales target for Europe but it is expected to have 49% BEV in its European production mix according to the IHS Markit production forecast and will be ramping-up production on its new dedicated E-GMP platform [20].

Six carmakers scored less than 50 points and appear to be less ambitious and prepared for the EV transition. With 47 points, **Ford** reaches fifth position largely thanks to its 100% BEV sales target for 2030 in Europe [21]. However, the American company is less involved in technological developments as it is expected to rely mainly on VW's MEB platform in Europe [22]. Moreover, Ford does not earn the maximum on the BEV ambition category as its 2025 BEV EU production plan is relatively weak (13% BEV): the OEM is expected to wait until the second part of the decade to accelerate its BEV production in Europe. **Stellantis** obtains 46 points and is ranked in sixth position. Notably, the OEM invested in the battery cell production joint venture Automotive Cells Company (ACC) [23] which is planning 2 gigafactories in Europe (one in France and one in Germany). With 46 points, **Daimler** has relatively low BEV sales targets as its 2030 50% target includes PHEVs [24], but it can rely on the EVA2 BEV dedicated platform [25] and its subsidiary Accumotive [26] for activities related to battery development, assembly and recycling. With 44 points, **BMW Group** targets 50% BEV sales by 2030 [27] but is not developing a true BEV dedicated platform, instead the Neue Klasse platform is expected to be compatible with ICEs and PHEVs [28]. **Jaguar-Land Rover (JLR)** scores 42 points mainly thanks to Jaguar's ambition to become fully electric by 2025 [29]. But the carmaker's smaller size might be a disadvantage in this ranking as it could be penalised because of smaller investment capabilities, for instance it could be more challenging for the British group to be as closely involved in battery production compared to other larger OEMs.

Finally, **Toyota** gets 35 points with no clear BEV ambitions. The Japanese OEM is slower in increasing BEV production as its strategy currently still relies to a large extent on HEVs despite the recent announcement of its new BEV lineup. Toyota has slipped from the leading green car company 10 years ago to being the least prepared for the electrification revolution that is underway.

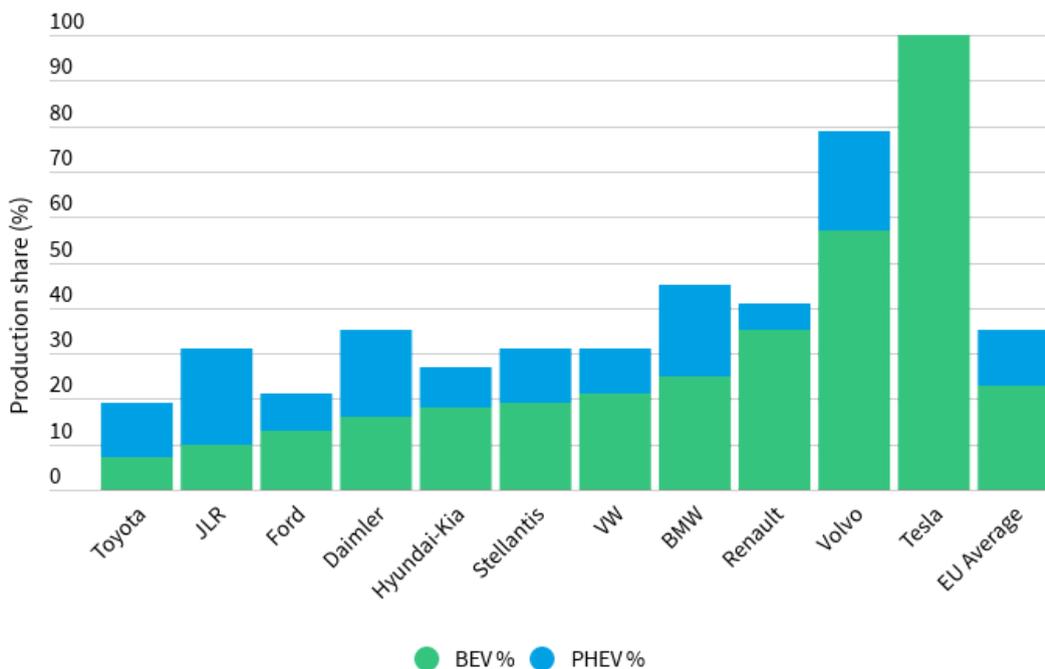
For each major carmaker, IHS Markit EU production forecasts for 2025 and 2030 are analysed in Section 3.2 while the number of new BEV models coming to the market up to 2027 are detailed in Section 3.3. On top of IHS Markit data and carmaker production plans, Section 3.4 provides an overview of OEMs industrial strategies including battery manufacturing strategies, charging and energy strategies or the use of BEV dedicated platforms. Moreover, the overview of each OEM production mix is presented in Annex 6.3 while the difference between production and expected sales is detailed in Section 4.1. PHEV technical specifications provided in the IHS Markit forecast are used in Section 3.5 in order to assess the performance of these future cars.

3.2. Carmakers production forecast in Europe

In this section, IHS Markit forecast data is analysed to describe in detail the production plans of the main carmakers producing in Europe¹⁵ and assess their coherence with regards to the EV transition. In short, the 2020s would see VW emerge as the incontestable leader of fully electric vehicles production in Europe but OEMs, such as Volvo or Ford, having smaller production volumes, are expected to achieve a higher share of BEVs in their own EU production mix. Some carmakers, BMW or Daimler, are expected to have a slower BEV transition as they are projected to keep a large amount of PHEV in their 2030 production plan in Europe.

2025 production forecast

IHS Markit 2025 car production forecast provides useful insights into the short term strategy of OEMs. Figure 10 breaks down the share of BEV and PHEV in carmakers 2025 production plans in Europe. In 2025, the EV transition is expected to be well on its way as more than one car out of three will be fitted with a plug: the EU27 + UK average production mix is expected to reach 23% BEV and 12% PHEV.



EU production may not reflect some OEMs' sales announcements (import/export not accounted or outdated production plans)
 Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 10: BEV and PHEV share in 2025 forecasted production in Europe

¹⁵ In the following sections, only major OEMs that are expected to produce more than 100,000 BEV in 2030 are included. In the case of Renault, results are given for the Renault Group (Renault, Dacia, Alpine) and not for the Renault-Nissan alliance, Nissan being considered here as a low volume manufacturer in Europe.

Note: only the production is taken into account in this analysis and it might not match OEM recent public announcements in terms of sales as the impact of imports/exports is not taken into account and OEMs might still have to define their industrial plans to back their commitments. This impact on European sales is commented on in Section 4.1 of this report. For instance, Renault EU production plans derived from the IHS Markit database do not reflect Renault brand latest commitments to 90% BEV and PHEV.

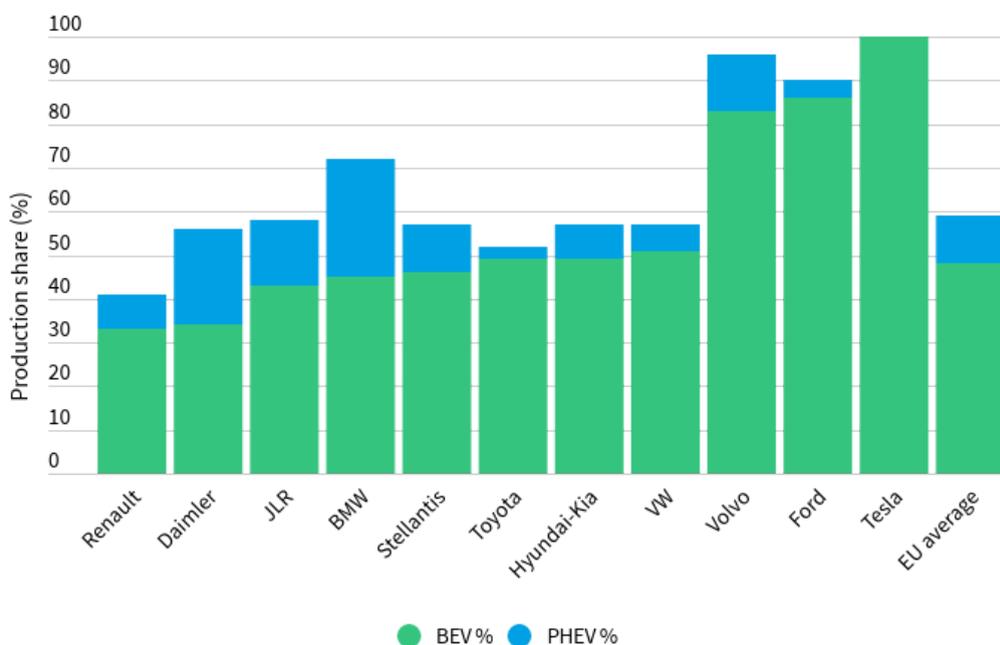
The first position goes to an all-electric carmaker: Tesla is expected to start European production in 2021-2022 and would reach the fourth position in production volumes in 2025. With 57% BEV produced in Europe in 2025, Volvo is expected to be the leading traditional carmaker for EU BEV production share, but the BEV volumes produced are relatively low as Volvo accounts for only 3% of the total EU car production. In the third position for EU BEV production share, the Renault Group would produce 35% of its cars in fully electric versions in Europe.

With less than 15% BEVs in 2025, Ford, JLR and Toyota would be the OEMs with the slowest BEV production ramp-up. Ford is expected to produce 13% BEV in its EU production mix, JLR would produce 10% BEV and Toyota is expected to be lagging behind in 2025 with only 7% of its European production full electric.

In terms of volumes, VW is expected to produce the highest number of fully electric cars with nearly a million units in 2025 accounting for 27% of the total EU BEV production share. Stellantis and Renault are expected to be the second and third largest electric car makers with 17% of the EU BEV production and 12%. Ford, JLR and Toyota are at the bottom of this ranking with less than 75,000 units.

2030 production forecast

Looking at the production forecast data for 2030 allows to assess OEMs strategies and ambitions in the medium and long term. For the whole EU27 + UK production, the share of BEVs is expected to reach 48% and PHEV would be at 11%. In this context, the state of BEV electrification is quite different from 2025 as some carmakers are expected to make important progress in the second part of the decade whereas others are stagnating.



EU production may not reflect some OEMs' sales announcements (import/export not accounted or outdated production plans)
 Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 11: BEV and PHEV share in 2030 forecasted production in Europe

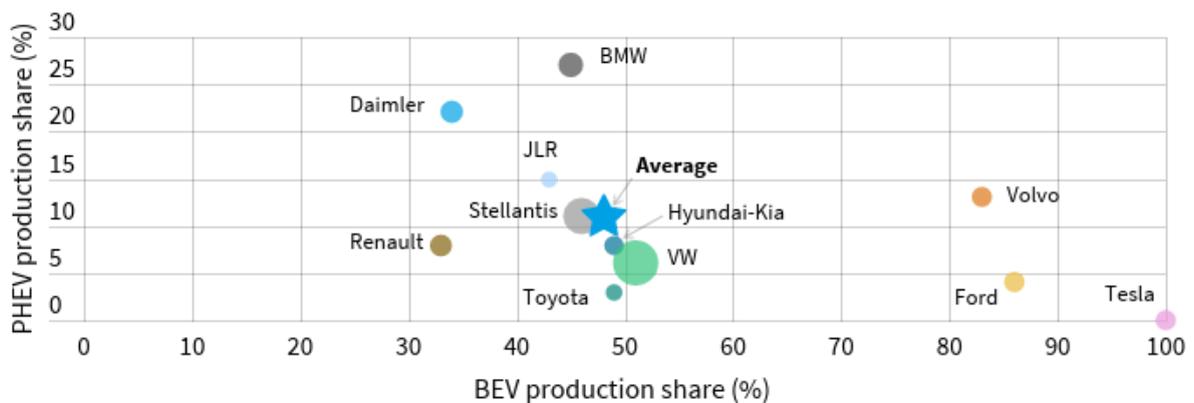
In 2030, Tesla is still expected to be the only OEM with 100% BEV production in Europe. Then, in second position, Ford is expected to reach 86% and Volvo 83% in third position¹⁶. Most other carmakers would have a BEV share around the European average of 48% while VW would be the only one of that group to exceed 50%. Daimler is among the carmakers with the lowest 2030 ambition as electric cars are expected to barely reach 34% of its 2030 production.

In terms of total EU BEV production share, VW is expected to consolidate its leading position in 2030 with a total BEV production exceeding 2 million units (around 30% of the EU BEV production). In second position, Stellantis is expected to exceed 1.3 million BEV produced (around 20% of EU production). Then, BMW is expected to produce less than 10% of the EU BEV production. Interestingly, Tesla is expected to fall to the 8th position (from 4th in 2025) as traditional car manufacturers are ramping up their BEV production. Toyota and JLR are still expected to be the OEMs with the lowest BEV production volumes with less than 250,000 units in 2030.

BEV vs. PHEV overview

While BEV production is growing, PHEV production is stalling but some carmakers are still expected to rely on the technology in their 2030 production plans in Europe. Stellantis and BMW would be the largest PHEV producers in 2030 followed by Daimler and VW.

Figure 12 below compares PHEV and BEV production¹⁷ share in Europe for each OEM in 2030, the size of the bubble is proportional to the BEV production volume. Daimler has a low BEV production but relies heavily on PHEVs. Closer to the BEV average share, BMW stands out with the highest PHEV share. Then, Volvo and Ford are expected to rely far less on PHEVs as they target a high level of fully electric cars.



EU production may not reflect some OEMs' sales announcements (import/export not accounted or outdated production plans)
 Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 12: Overview of BEV and PHEV share in OEMs 2030 production. Area of circles represents relative BEV production volumes.

¹⁶ Both Ford [21] and Volvo [10] have 100% BEV sales targets in 2030. The difference between EU production and sales could also be explained by ICEs produced in Europe dedicated to exports, or OEMs plans are not updated yet.

¹⁷ OEMs BEV and PHEV EU sales could be different from their EU production as OEMs could produce some models outside EU (for instance Daimler has PHEV production in the US) and some are likely to be imported.

Carmakers' battery demand

As BEV production is ramping up and the average battery capacity is increasing, battery demand is also bound to increase significantly. According to the IHS Markit database, the total battery demand for the cars produced in the EU27 + UK is expected to exceed 250 GWh in 2025 and exceed 500 GWh in 2030 (see Figure in Annexe 6.4). VW is expected to have the highest demand in 2030 (more than 170 GWh) but the German group is also the one with the most ambitious battery plans (see Section 3.4). In second place, Stellantis would need more than 80 GWh of battery to produce its EVs in 2030.

With more than 20 gigafactories planned in Europe and a battery production capacity that is projected to exceed 460 GWh in 2025 and 730 GWh in 2030, there is no shortage of European made batteries expected.

3.3. ZEV models available on the market

This section is based on the IHS Markit production forecast and in-house analysis to quantify the number of ZEV (BEV or FCEV) models available on the European market. To do so T&E has looked into market launch dates for upcoming ZEV models as well as models produced abroad which are expected to be imported in Europe.

Methodology: This analysis only covers cars and this excludes vans. For models offered in more than one version, only one model per nameplate is counted. In order to largely exclude niche carmakers and models, the analysis was restricted to models produced in reasonably high volumes¹⁸. Niche carmakers which already have electric vehicles on the European market (or will launch one by 2022) are grouped in the “Others” category¹⁹. Where market launch dates are not available, it is assumed that there is a three month delay between the start of production and the start of sales. Additionally, where information is not available regarding whether a model is intended for the European market, it is assumed that models produced in the European Union or the United Kingdom will be on sale in Europe while those produced abroad are intended for foreign markets.

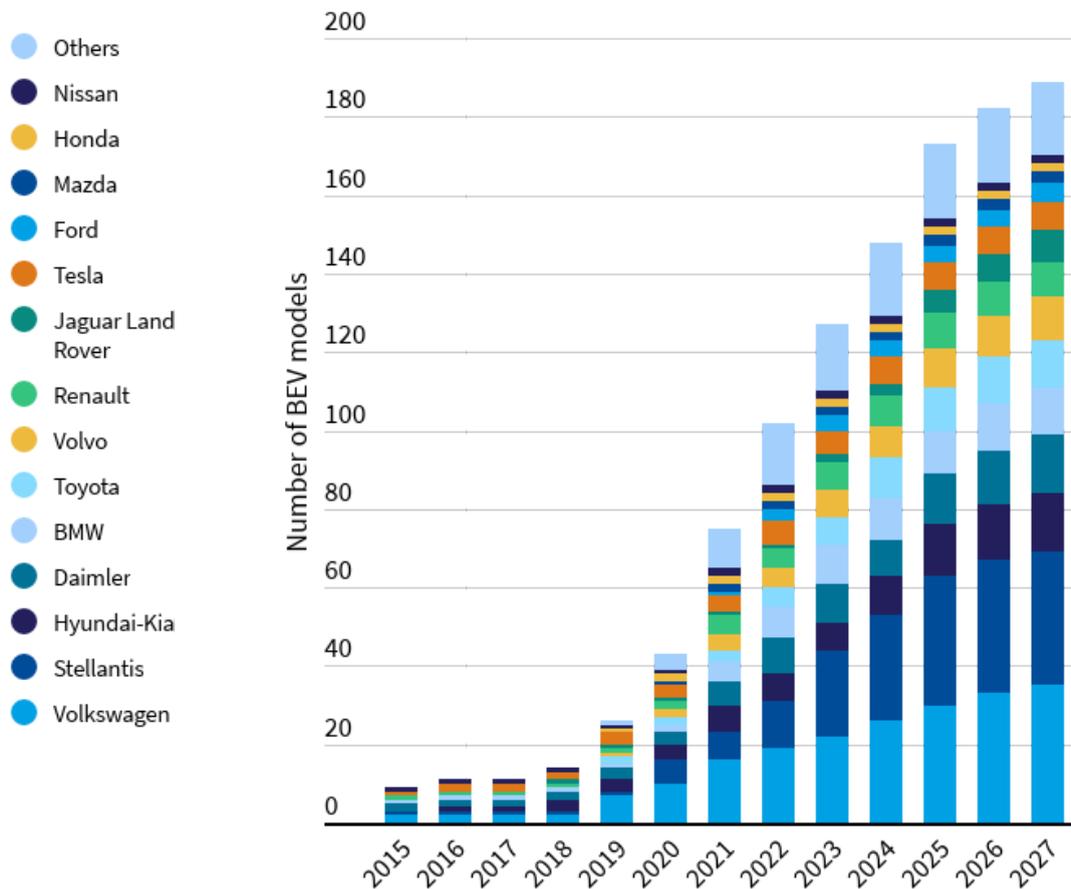
Battery Electric Vehicle (BEV) models

The number of BEV models on the European market has been surging due to the 2020/21 CO₂ emissions standards: it jumped from 26 BEV models available in 2019 to 43 in 2020 —a 65% year-on-year increase— and again to 75 in 2021 —a 74% year-on-year increase. Carmakers are set to continue diversifying their BEV portfolio until 2025, when the CO₂ standards will be tightened once

¹⁸ For European models, only those produced in at least 1,000 units in at least one year by carmakers producing at least 30,000 units over 2021-2027 were considered. For non-European models, only those produced in at least 10,000 units in at least one year by carmakers producing at least 300,000 units globally over 2021-2027 were considered.

¹⁹ Assessed based on EV-database [30] model availability data. ‘Others’ include Aiyways, Byton, Fisker, JAC, Lexus, Lightyear, Lucid, MG, Seres, and Sono. Note that Polestar is included with the Volvo brand under Volvo.

more. In 2025, the number of BEV models available is expected to reach 173 (25 new models in that year alone). The number of BEV models available would then increase more slowly, growing only by 5% in 2026 and 4% in 2027. This boom of the number of BEV models available in 2020/21 and again (to a more limited extent) in 2025 illustrates that carmakers are planning their product launches to coincide with new CO₂ targets—demonstrating that the European EV market is to a great extent still compliance-driven.



Source: T&E analysis of carmaker announcements and IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

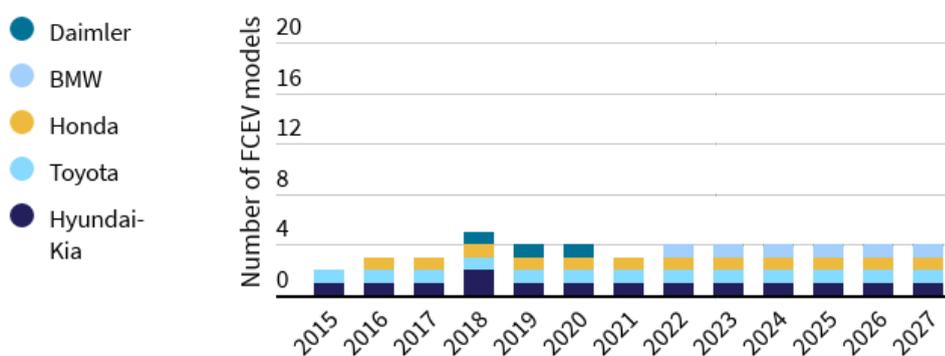
Figure 13: Number of BEV models on the market in Europe through 2027

VW leads the market with 16 models in 2021, 30 in 2025, and 35 in 2027. Stellantis follows with 7 models in 2021, 33 in 2025, and 34 in 2027. They are trailed by Hyundai-Kia and Daimler, which offer 7 and 6 models respectively in 2021, 13 in 2025, and 15 in 2027. BMW and Toyota both are expected to offer 11 models in 2025 and 12 in 2027. Volvo (including its Polestar brand) will offer 10 BEV models in 2025 and 11 in 2027. All other car makers are expected to offer fewer than 10 BEV models each through 2027.

As the analysis only covers cars and this excludes vans, it includes fewer BEV models than compared to T&E's 2019 report (which includes vans) up to 2024-5. Nonetheless, in both analyses, the number of new ZEV models being launched peaks in 2020/21 and 2025²⁰, when regulation is strengthened.

Fuel Cell Electric Vehicle (FCEV) models

Very few fuel cell vehicles are on the market today or are expected to come to the European market in the next few years. Only four models were on sale in 2019 and 2020 (Toyota Mirai, Honda Clarity, Hyundai Nexo, and Mercedes GLC F-Cell), 3 in 2021, and 4 from 2022 onwards. Previous T&E analysis [31] based on 2019 IHS Markit data expected at least 10 FCEV models to be offered from 2023 onwards. However, both VW [8] and Daimler [7] have since discontinued their fuel cell development, deeming it too expensive and prioritising BEV models over FCEV ones. This leaves only BMW, Honda, Hyundai and Toyota in the fuel cell market, each offering one vehicle in Europe from 2022 onwards²¹.



Source: T&E analysis of carmaker announcements and IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 14: Number of FCEV models on the market in Europe through 2027

3.4. Industrial transition commitment

On top of OEMs expected production plans and the analysis of IHS Markit database, T&E undertook a comprehensive assessment of carmakers strategies regarding the industrial transition towards BEVs. This qualitative assessment of industrial strategies related to EV architecture (e.g. platforms), batteries and charging infrastructure aims to provide a wider and more accurate picture of carmakers engagement and commitment. It includes relative ranking based both on the level of ambition in the different categories and the timing of the strategy as early planning and achievements are required to support the ambitious growth of the whole EV industrial ecosystem.

²⁰ In 2019, T&E forecast that the number of new ZEV car and van models would peak at 34 in both 2020 and 2025. This analysis shows the number of new ZEV car models peaks in 2021 at 32 and in 2025 at 25.

²¹ They are the BMW X5, the Honda Clarity Fuel Cell, the Hyundai Nexo, and the Toyota Mirai.

The ‘industrial strategy’ rating is a qualitative rating designed by T&E to assess OEMs’ involvement and strategy in three areas which are essential for a successful transition to BEVs (more details of each criterion are given in Annex 6.5.2):

- the development and use of a platform dedicated to fully electric car today, in 2025 and in 2030 (out of 20 points)²²,
- the planning of a long-term battery strategy including battery cells manufacturing, ethical raw material sourcing, recycling and new battery technology research (out of 20 points),
- the investment and commitment towards private and public charging and energy infrastructure (out of 10 points).

Table 2: Industrial strategy rating

OEM	BEV Platform (/20)	Battery Strategy (/20)	Charging & Energy Strategy (/10)	Industrial Strategy (/50)
VW	20	18	7	45
Volvo Cars	12	14	3	29
Daimler	9	14	6	29
Renault	8	12	6	26
Hyundai-Kia	16	6	3	25
Stellantis	6	12	6	24
BMW	0	15	6	21
Toyota	16 ²³	4	1	21
Ford	4 ²⁴	12	3	19
JLR	4	9	3	16

VW Group is the most committed to the BEV industrial transition with 45 points. The German carmaker was the first traditional carmaker to use a BEV dedicated platform (MEB [14]). Its battery strategy includes building 6 gigafactories (240 GWh) [13]. It will rely on in-house production, as VW Group Components plan to produce its cells in Salzgitter [32] and Porsche is expected to have its own high performance cells production [33], but also on partnerships as VW holds a high stake in the Swedish cell manufacturer Northvolt [34] and it has strategic partnership with SK Innovation, LG Chem and CATL. VW is also planning an in-house recycling process with the Volkswagen Group Components subsidiary [35]. In addition to its support to the deployment of 18,000 public fast charging stations [13] as part of the Ionity network or in partnership with Enel, Iberdrola, BP, and ARAL, the carmaker created the subsidiary Elli [16] for the group's energy and charging solutions.

²² Platforms designed for BEV but that can be used for PHEVs are not considered as an efficient and optimized technical solution.

²³ Toyota is advantaged in this category because it has very few BEV models but they are based on the e-TNGA dedicated platform from 2022. Toyota is still among the laggards as, in Europe, it is expected to produce only 7% BEV in 2025 (accounted in the BEV ambition ranking, see Annex 6.5.1).

²⁴ As Ford is expected to mainly use VW’s MEB platform in Europe, the rating is limited in this category.

Volvo is ranked in second position with 29 points. The Swedish carmaker is committed to fully move to BEV dedicated platforms as it targets 100% BEV in 2030, and will notably use the SEA platform of its parent company Geely and the Scalable Product Architecture (SPA 2) that is expected to be used with a floor dedicated to BEV produced on a separated production line [11]. In addition to the joint venture of its parent company Geely with Farasis [36], the OEM has long-term partnership for battery supply with CATL and LG Chem and has a battery assembly plant in Belgium. The OEM is involved in the circularity of battery materials and the ethical sourcing of the raw materials. For instance, Volvo is developing an in-house battery recycling process [37] including hydrometallurgy so that recycled battery materials can be used in new cells. Regarding material sourcing, the carmaker has a partnership with Circular and Oracle to operate a blockchain technology to track cobalt across CATL supply chain, and it is part of the Responsible Sourcing Blockchain Network to apply IBM blockchain technology in LG Chem's supply chain. Regarding the support of charging and energy infrastructure, Volvo launched the Volvo Recharge Highways project in Italy to roll out public fast-charging stations and is also part of the V2X Swedish Project to accelerate the development of Vehicle-To-Grid (V2G).

In third position, **Daimler** scores 29 points with a coherent battery strategy that includes a global battery pack production network of nine factories with its Accumotive subsidiary [26] -that is also in charge of battery developments and recycling- and long-term battery cell manufacturing partnership with CATL and Farasis in Germany. Daimler is part of the DCS [38] joint venture with BMW for charging solution services and it invested in The Mobility House, a charging solutions provider that operates stationary energy storage systems built with EV batteries. Daimler is expected to use the EVA2 all-electric platform from 2021 for its executive and luxury class vehicles, and the German manufacturer plans the MMA platform for its compact and middle class vehicles from 2025. The MMA is designated as an “electric first skateboard platform” but it is not designed for 100% BEV only and plug-in hybrid powertrains can be added [39].

Renault (26 points) is committed to battery circularity as its Flins plant in France is expected to become its new hub for a circular economy [19] and it is now part of a battery recycling consortium with Veolia and Solvay . For its battery supply, Renault is expected to rely on Envision AESC that plans new battery factories in Sunderland (UK) [17] and Douai (France) [18], as well as on supply from LG Chem and CATL. The French group is also assembling its battery packs in Douai (France), with Nissan in Sunderland (UK) and at Cacia (Portugal). Regarding charging, Renault relies on Elexent [40], its subsidiary dedicated to commercial fleet charging solutions, and Mobilize for smart charging solutions. Renault is planning to use the BEV dedicated CMF-EV platform [41] for the larger cars of the Renault-Nissan-Mitsubishi Alliance from 2021-2022.

Hyundai-Kia gets 25 points mainly thanks to the development of its BEV dedicated platform (the Electric Global Modular Platform, E-GMP [20]) that is expected to be used for all its electric vehicles from 2021 with the launch of the Hyundai Ioniq 5. Regarding battery supply, the Korean OEM might use cells produced by SK Innovation in Hungary or LG Chem and CATL, and it leads its battery assembly process in Czech Republic. The OEM also joined the Ionity fast charger network in Europe.

Stellantis (24 points) is mostly involved in battery manufacturing with its joint venture Automotive Cell Company [23] that plans 2 gigafactories (50GWh cell production in 2030) near Douvrin in France and

Kaiserslautern in Germany and the group is planning battery pack assembly lines in Slovakia, Spain and Italy. In addition, the group suppliers include Svolt with production in Germany, LG Chem in Poland and CATL. Stellantis is part of the Free2Move eSolutions [42] joint venture with Engie for a wide range of solutions from charging infrastructure, home charging subscriptions and advanced energy services. Stellantis has an unclear strategy regarding BEV platforms: the latest announcements presented four “BEV focused” platforms [43] (STLA Small, Medium, Large and Frame) but some of these could be compatible with PHEV production (which would make them closer to multi-energy platforms than 100% dedicated platforms).

BMW (21 points) has a coherent commitment to battery manufacturing with long-term partnerships: the German carmaker invested in Northvolt [44] while its suppliers CATL will produce units in Germany and Samsung batteries are made in Hungary. The OEM is also expected to use three battery module assembly lines in Germany. Regarding battery material supply, BMW is directly sourcing critical raw materials from mining companies: lithium comes from Australian and Argentina mines, cobalt from Morocco and Australia and nickel is supplied from Russia. BMW is part of the Ionity high-power charging network and the DCS [38] joint ventures with Daimler to develop public charging solutions for OEMs and fleet operators. Nevertheless, the carmaker underperforms in the BEV dedicated platform category as it has not chosen to develop a separated BEV platform: the Neue Klasse platform is expected to be a multi-energy platform that would underpin vehicles with gasoline and diesel ICEs and PHEVs [28].

Toyota scores 21 points with its “e-TNGA” all-electric platform that will be launched with the Toyota bZ4X SUV production in 2022 [45]. The Japanese carmaker has a joint venture with Panasonic for its future solid state battery development. Regarding the charging strategy, it appears to have little involvement in the sector except an investment in Nuvve that leads V2G projects.

Ford (19 points) is among the laggards of the industrial strategy ranking mainly due to the lack of clear and ambitious strategy for Europe (a strategy was recently announced but it focuses on the USA). As part of this recent strategy, Ford launched a joint venture with SK Innovation [46] for battery manufacturing in the US and started R&D at the new Ford Ion Park battery center in Michigan [47]. The American carmaker is planning to produce 100% of its BEVs on electric platforms in 2030 but the group has announced it will rely on the VW MEB platform in Europe [22] and its own newly announced BEV platforms are expected to be deployed essentially in the USA [48] in the second part of the decade (hence the limited rating on this category). Ford is also part of the Ionity charging network.

JLR ranks last with 16 points: the OEM is disadvantaged by its small scale, but its “Reimagine” strategy presented early 2021 could allow the British carmaker to improve its ranking in the near future. As the carmaker has also invested in different activities, such as Circulor’s blockchain technology for the tracking of raw materials or Battery Resourcers’ process for battery recycling, it would eventually reap the benefits of today’s investments. JLR is also planning a BEV dedicated platform for its Jaguar brand from 2026 while Land Rover models are expected to still use a platform common with PHEVs [49] in the future. Regarding charging infrastructure, the British carmaker partnered with NewMotion for the deployment of fast chargers in the UK.

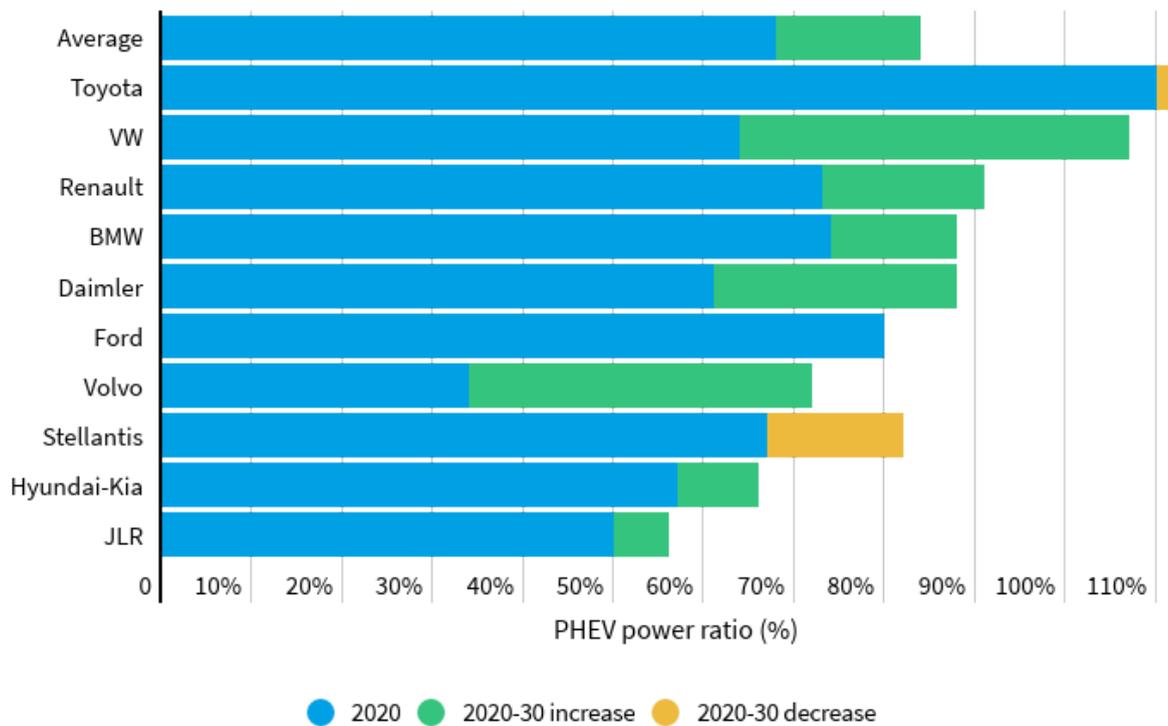
3.5. Rating OEM PHEV plans

In this subsection, the specifications of PHEVs are analysed in detail. Two indicators are used to assess the design and performance of the PHEVs planned for production: the ratio of e-motor power to ICE power and an electric range proxy metric. These metrics are calculated from the power and battery size specifications as provided by the IHS Markit forecast or OEM information. They are designed to carry out an indicative assessment of carmakers' relative performance with regards to expected PHEV plans and strategies. This assessment is based on what T&E considers to be an acceptable PHEV: electric motor power superior to the power of the conventional engine as well as a real world range above 80 km in 2020, as shown in T&E PHEV report from 2020 [4]. Such well-designed PHEV could be a transitional technology compatible with the pathway towards reaching zero emission for all new cars by 2035 at the latest. Indeed, if PHEVs are designed to be used in zero emission mode in all driving conditions and in most daily travels, they could reduce both CO₂ emissions and other pollutants (e.g. particulate matter, nitrogen oxides) in the real world. Conversely, if PHEVs are only optimized in WLTP lab tests as a compliance tool, then they would fail to provide any real and ambitious emissions reductions (Info Box in Section 1.2.1).

PHEV power metric

To achieve substantial CO₂ savings, PHEVs need to be able to drive in zero emission mode without starting the polluting engine in all driving conditions, including during fast accelerations, uphill driving, or when auxiliaries, such as air conditioning or de-misters, are in use [50]. This means that the plug-in hybrid electric motor power should be, at a minimum, equal to the power of the ICE, otherwise the conventional engine will always turn on when the power needed is higher than what the fitted electric motor(s) alone can provide. This is undesirable as frequent use of the ICE reduces the CO₂ and air quality benefits of PHEVs.

Here, a PHEV power ratio of 100% would mean that the power of the electric motor is equal to that of the ICE. As shown in Figure 15, T&E's analysis shows that in 2020 the average power ratio of PHEVs produced in the EU was only 68% and it will only improve to 84% by 2030. Despite the modest improvement, the average PHEV e-motor power is thus still expected to be lower than the ICE power by the end of the decade.



Source: T&E internal modelling based on OEM e-motor data and IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 15: Ratio e-motor power over ICE power for PHEVs produced in Europe in 2020 and 2030

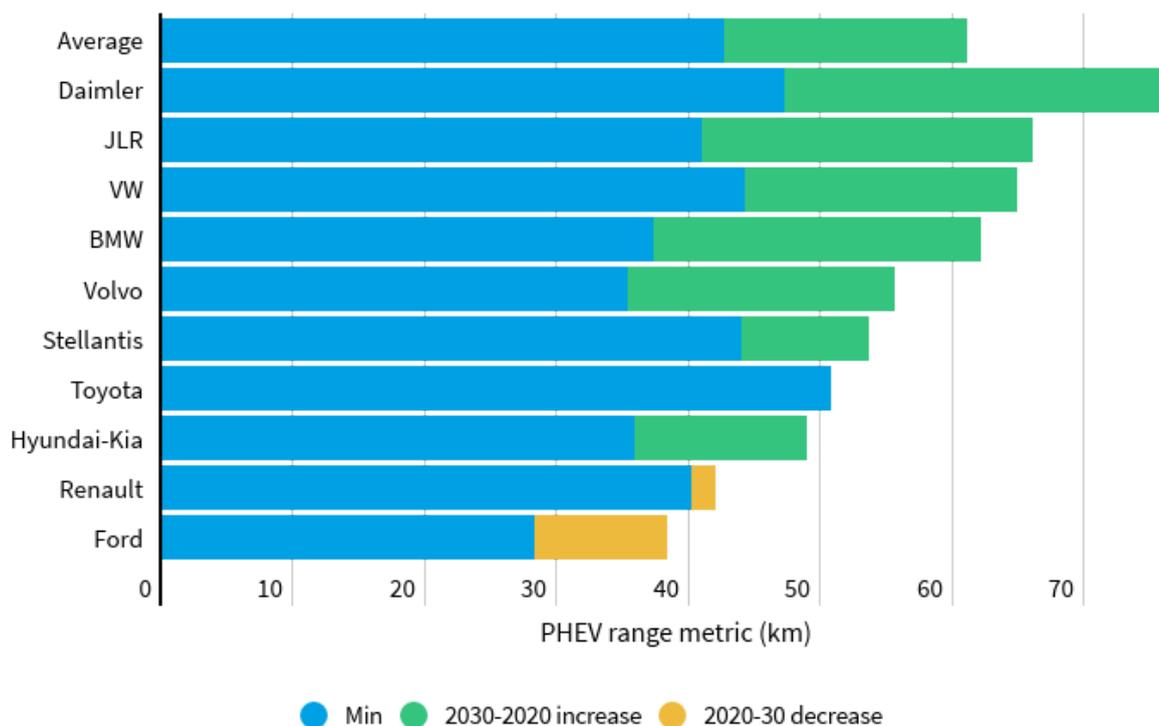
Toyota is the best performer in the metric both now and 2030. In 2030, it is expected to produce only one PHEV model in Europe: the Corolla’s electric-only power is expected to be 10% higher than the ICE power, indicating that the production of such PHEVs is both technically and economically feasible. VW’s PHEVs should, on average, perform second best by 2030, improving from 64 to 107% thanks both to higher e-motor powers and a higher share of all-wheel drive (AWD) versions able to be driven in electric mode by two e-motors (one on the front drivetrain and one on the rear).

Among the laggards, PHEVs produced by Stellantis are projected to decrease to a 67% power ratio as the share of Stellantis AWD versions is expected to decrease and hybridisation is expected to be increasingly used with high power ICEs. In last position, JLR would be the worst performing with only 57% PHEV e-motor power ratio. Overall, 27% of PHEVs produced in 2030 are expected to have a power ratio over 100% (20% of models when averaged over all the model variants). Among these best performing popular models, the VW Golf is projected to have a 123% ratio, the BMW 3-series model would reach an average ratio of 113% and the Toyota Corolla 110% (values are averaged over model variants). Conversely, some models are expected to have relatively low power ratio, for instance the future Audi A4 power ratio would be as low as 24%, the Volvo V90 41% or the Alfa Romeo Stelvio 50%.

PHEV electric range proxy

The PHEV electric range proxy is an estimate of PHEVs ability to drive using the battery only (i.e. in zero emission mode) in real world conditions. It is calculated from parameters available in the IHS Markit

database and OEM information: the battery capacity of the vehicle, its segment, and its power²⁵. This range proxy metric is not designed to calculate the exact electric range of a specific car model but rather to assess the overall trends per segment or carmaker.



Source: T&E internal modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 16: range proxy of PHEV produced in Europe in 2020 and 2030

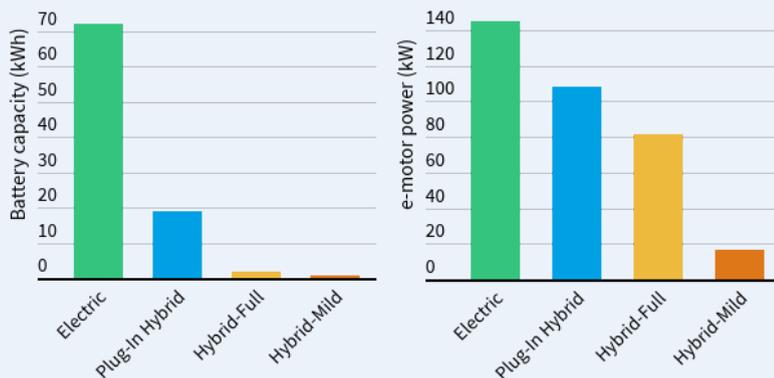
Based on the range proxy, the average PHEV produced in 2030 in Europe is expected to have a range which is 43% longer than in 2020. Daimler, the best performing carmaker, is increasing its range proxy to 77 km in 2030 from 47 km in 2020. This is thanks to the use of some of the largest PHEV batteries in 2030, with capacity of up to 30 kWh in high-end models (around 25 kWh on average). This is higher than the BMW X5, the current longest range PHEV on the market with a capacity of 24 kWh and a range proxy of 69 km²⁶. On the other side, the range proxy calculated for Ford is expected to decrease as IHS Markit forecast that its last PHEV model produced in Europe before 2030 is projected to only use a battery with a capacity lower than 8 kWh.

²⁵ These parameters are subjected to the same uncertainty as the whole IHS Markit forecast. The range proxy is meant to be a numerical value whose order of magnitude is consistent with the range driven in electric mode in real world conditions. This proxy is not a forecast of the WLTP electric range that would be relevant only in lab test conditions. More details are provided in Annex 6.6.

²⁶ In the real world, T&E measurement [4] shows the X5 can drive 75km in electric mode under mild/moderate driving conditions in line with the requirements of the EU Real Driving Emissions (RDE) test procedure, but under more dynamic conditions, the electric range falls to only 18km.

Even though battery prices are expected to drop over the next decade, most carmakers will use batteries with a capacity lower than 20 kWh, around a quarter of the average BEV capacity of 72 kWh. This will restrict the range proxy of most PHEVs to just 61 km while only 10% of PHEVs produced in 2030 are expected to reach an 80 km range in zero emission mode (4% of models when averaged over all the model variants). Among the best performing models, the future Mercedes E-class could reach a 91 km real world range while the future Renault Kadjar could be limited to 33 km (values are averaged over model variants).

PHEV specifications are closer to hybrids than BEVs



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April

Figure 17: Average e-motor power and battery capacity of car produced in Europe in 2030

PHEV e-motor power and battery capacity are closer to hybrids than BEV: With an average power expected to be around 110 kW and a battery capacity below 20 kWh, PHEVs fall short of the performance and specifications required to compete with fully electric cars.

PHEV overall performance: only ‘fake electrics’

Despite some improvements, no major carmaker is expected to produce PHEV models in Europe with both a powerful e-motor and an estimated range above 80 km in 2030 (production distribution detailed in Annex 6.7), which could be considered as acceptable PHEVs i.e. both technically capable of driving zero emission under all conditions and with a long real world electric range. Indeed, models which have an e-motor at least as powerful as the ICE, are not expected to exceed a 80 km range when averaged over the model variants²⁷. In reality, the average PHEV produced in the EU in 2030 will be fitted with suboptimal technology, achieving an electric range of just 61 km and ICE/e-motor power ratio of 84%.

These findings highlight that the European PHEV market has moved away from range extender models such as the BMW i3²⁸ and largely directed towards compliance PHEVs which are designed to achieve CO₂

²⁷ Models may have different variants with different powers. In a few particular cases, an all-wheel drive configuration (AWD) is used with an additional e-motor. AWD variants thus have more e-power and some also have larger batteries. Therefore, some hatchback models with an AWD version and larger batteries would reach the 80km range but these high performance variants are produced in lower volumes than the standard variants, leading the production-weighted average of the nameplates to be below 80km.

²⁸ The i3 range extender version is using a specific hybrid configuration (hybrid series): the ICE is not driving the car, instead it is used to generate electricity to power the e-motor or recharge the battery.

reductions on paper but not on the road. The BMW i3 range extender version -which will not be produced anymore from 2022- have both a long electric range of 165 km²⁹ and a powerful e-motor (125 kW), allowing the car to be driven predominantly in zero emission mode. The ICCT studied the share of electric kilometers driven by different PHEVs in real world (a.k.a real world utility factors) and showed that range extender models are driven significantly more in electric mode (for instance, i3 models driven in Germany have a 86% utility factor while the average PHEV has only a 20-37% utility factor [5]). Based on the data available, no carmaker is planning to produce range extenders in the 2020s.

The reasons why carmakers are focusing on suboptimal PHEV technology are two-fold. Firstly, car makers are generously rewarded for the sale of low power and low range PHEVs, so there is no incentive to improve. Unrealistic regulatory assumptions on the utility factors (a PHEV often needs to drive at least 70% of time in electric mode to hit its sticker CO₂) mean that most PHEVs achieve very low CO₂ emissions of 50 gCO₂/km or less, in the lab. Sales of low CO₂ PHEVs reduces carmakers' fleet average CO₂ emissions making it easier to meet CO₂ targets and avoid fines. Additionally, sales of PHEVs with emissions of less than 50 gCO₂/km are further rewarded within the cars CO₂ regulation through Zero and Low Emission Vehicle (ZLEV) Credits [54], again making it easier for carmakers to comply with their CO₂ targets. Neither the procedure for determining CO₂ emissions nor the car CO₂ regulation requires car makers to improve their PHEVs so there is no strong regulatory driver for longer real world ranges and sufficiently powerful electric motors [55].

Secondly, fully electric cars are expected to become the dominant drivetrain technology within the EU with further improvements both in terms of performance and price competitiveness expected in the next decade. Recent research shows that most BEVs are expected to reach price parity with conventional ICEs by 2026 [3]. As such, carmakers are likely to prioritize BEV technologies rather than investing in more complex and expensive hybrid technologies with a limited shelf life.

Consequently, OEMs are largely planning to produce poor PHEVs mostly fitted on large and premium cars (for instance 23% of cars produced in segment E are PHEVs in 2030 whereas the EU average production is 11% PHEV) where the higher cost of a dual propulsion system is more acceptable (lower customer price sensitivity and higher OEM product margins absorb the additional overall costs). Moreover, large cars also provide more space to fit an additional electric propulsion system whereas it is more technically challenging to fit it in a compact car without major impacts on passenger space or boot capacity. The current CO₂ regulation which indirectly promotes heavier vehicles³⁰ is also driving OEMs to shift their large and polluting ICEs to PHEVs as it allows them to reap the largest CO₂ compliance benefits without bringing much change to the design and architecture of these large ICE vehicles (i.e. only adding a small battery and e-motor). In many countries PHEVs also get fiscal incentives and are an effective way for carmakers to avoid the tax malus on large and polluting ICEs (e.g. in France).

²⁹ With the 33.3 kWh battery (94 Ah): EV-database real world range: 165 km [51]. EPA range: 156 km [52]. Up to 200 km in electric mode according to BMW [53].

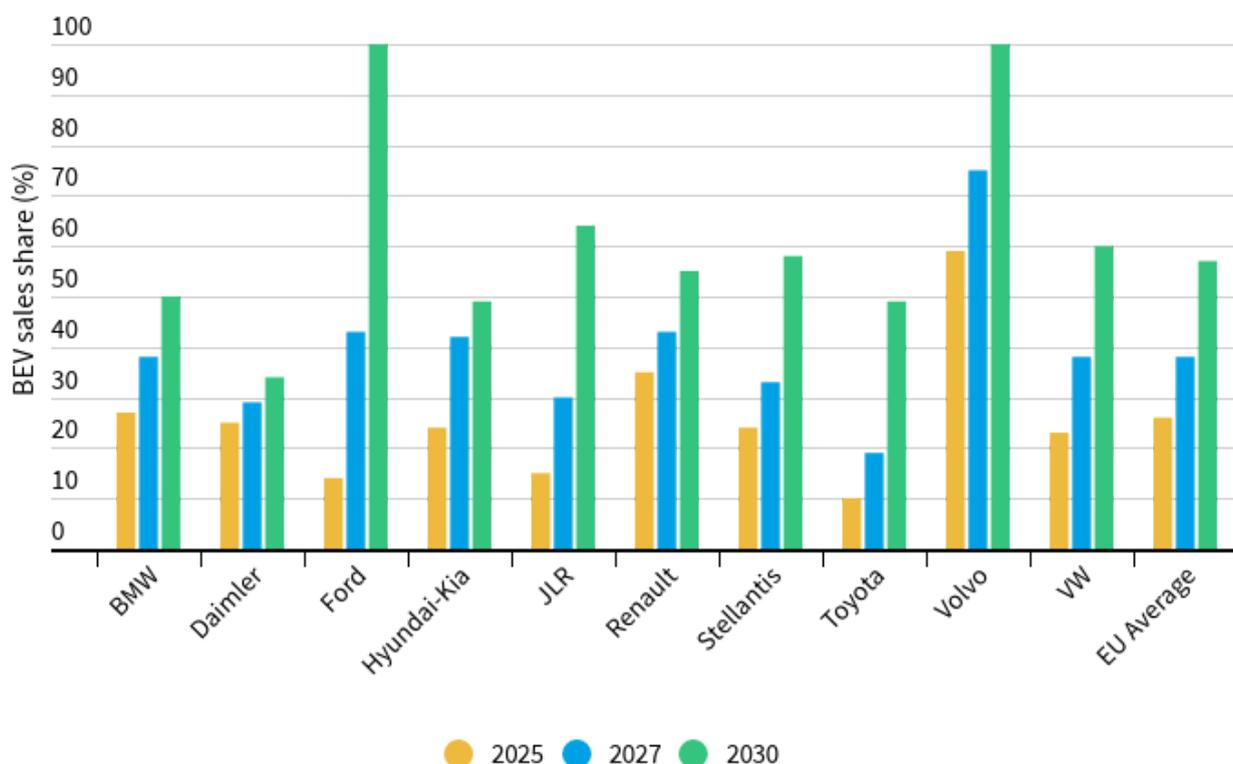
³⁰ With the mass-adjustment flexibility under the current regulation, each carmaker's target is increased (i.e. relaxed) if the average mass of the cars sold in a given year by the OEM is higher than the overall reference mass used in that year.

4. Implications for the European market and regulation

4.1. From production to sales

The figure below presents the estimated BEV sales share of each OEM in 2025, 2027 and 2030 according to assessment of OEMs commitments and trends based on the IHS Markit EU production forecast. With the inclusion of these sales target announcements, BEVs are expected to reach 26% BEVs in 2025, 38% in 2027 and 57% of the EU27 + UK market in 2030 compared to 23%, 34% and 48%, respectively, for EU production only.

The expected share of PHEV sales peaks at 13% in 2025 and stays at 13% as well in 2030. In other words, the share of BEV sales in the plug-in mix increases from 51.5% in 2020 to 66% in 2025, 75% in 2027 and 82% in 2030.



Source: T&E assessment of OEMs announcements and modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 18: Assessment of carmakers EU BEV sales share in 2025, 2027 and 2030

In 2025 and 2027, the relative difference between BEV sales and production for the whole EU27 + UK market is assumed to remain the same as it was in 2020 where 4.8% BEV were produced according to IHS Markit data and 5.4% BEV were sold [\[1\]](#) (1.13 sales to EU production ratio) whereas 2030 EU sales is calculated with OEMs commitments (it implies a 1.18 sales to EU production ratio). In 2025 and 2030, the carmakers' BEV sales shares are assessed based on their public commitments (Annex 6.8), their

production plans and the coherence with import and export options³¹, while the 2027 sales share is calculated from their 2027 production levels and the ramp-up required to meet 2030 targets. Regarding OEM public commitments that refer to electrified vehicles including PHEVs or to a specific brand, the share of BEV in electrified vehicles and the share of each brands are assumed to be same as the IHS Markit EU production forecast³².

This methodology leads carmaker results to have a higher BEV sales share as the EU BEV production share and this difference is justified by the impact of BEV imports and ICE exports:

- Part of ICE production in Europe would be exported toward emerging countries with lower regulatory requirements than the EU. Conversely, almost all BEVs produced in the EU are expected to be sold in Europe as OEMs will rely on those cars to comply with European CO₂ standards.
- Some carmakers have BEV production capacity in countries located close to the EU while others have models produced in China for the EU market and a part of this production capacity is likely to be dedicated to the EU market³³.

4.2. Comparison with a Green Deal compliant trajectory

Recent analysis from BloombergNEF has shown that, to put the European market and industry on a trajectory compliant with an ICE-phase out in 2035, BEV sales need to reach 22% in 2025, 37% in 2027 and 67% in 2030 in the EU. As shown by T&E [59], the EU needs to reach 100% ZEV sales in 2035 at the latest if it wants to be compliant with its own Green Deal climate ambition of climate neutrality by 2050. In this subsection, T&E compares the estimated carmaker's BEV sales ambition with this trajectory to understand how ambitious the sales and production levels really are. It should be highlighted that forecasted BEV sales estimates are inherently uncertain and carmakers plans are in constant evolution. The next subsection will explore how EU regulation can mitigate this high uncertainty while providing the necessary guarantees for a successful transition to BEVs.

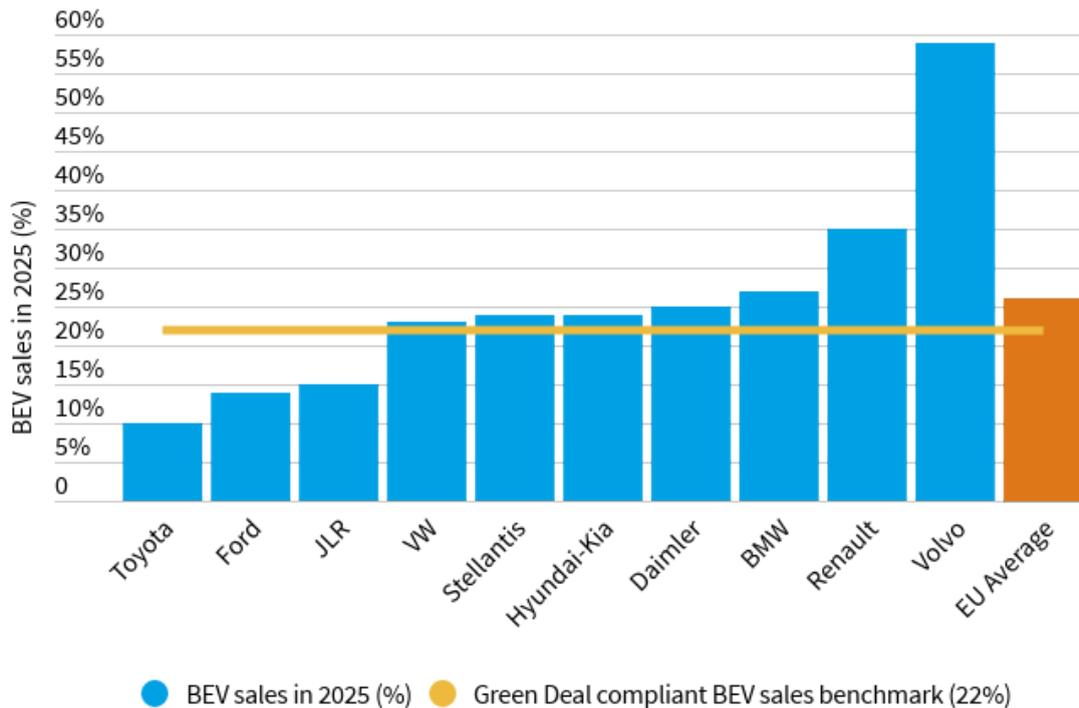
³¹ All the carmaker's 2025 and 2030 sales commitments are considered to be coherent with IHS production forecast and potential import/export options. The import and export options were assessed taking into account the planned EU BEV production capacity in 2025 and 2030 and the coherence with the order of magnitude of 2019 imports/export data (calculated from the difference between IHS Markit EU production data and EEA registration data [56]).

³² For instance, in the case of Stellantis, a 70% "electrified" target was announced [57] and it is translated into a BEV target according to the ratio of BEV and PHEV proposed by the IHS Markit EU production forecast (with additional assumption that Fiat produce 100% BEV in Europe [58]) thus amounting for 58% BEV sales. JLR announced targets of 100% BEV for the Jaguar brand and 60% for the Land Rover brand [29] which is converted into a group target of 64% in 2030.

³³ For instance, in 2030, the Peugeot e208 is expected to be produced in Morocco, the Fiat Panda in Serbia and the Fiat Tipo in Turkey, and the Dacia Spring is produced in China. Two thirds of the production of these models is assumed to be dedicated to the EU market and are included with the EU production for calculations.

2025 BEV share comparison

In 2025, the BEV share of sales compatible with the Green Deal ambitions would be 22%. As shown in Figure 19, the EU estimated sales are expected to achieve this target with an EU average BEV share of 26% thanks mainly to the early commitment of Volvo (59% estimated BEV share) and Renault (35% estimated BEV share). Most other carmakers³⁴ are expected to have sales levels in the 23-27% range that is consistent with the Green Deal scenario. Only Toyota, Ford and JLR are expected to lag behind with BEV estimated sales shares between 10 and 15%.



Source: T&E assessment of OEM announcements and modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

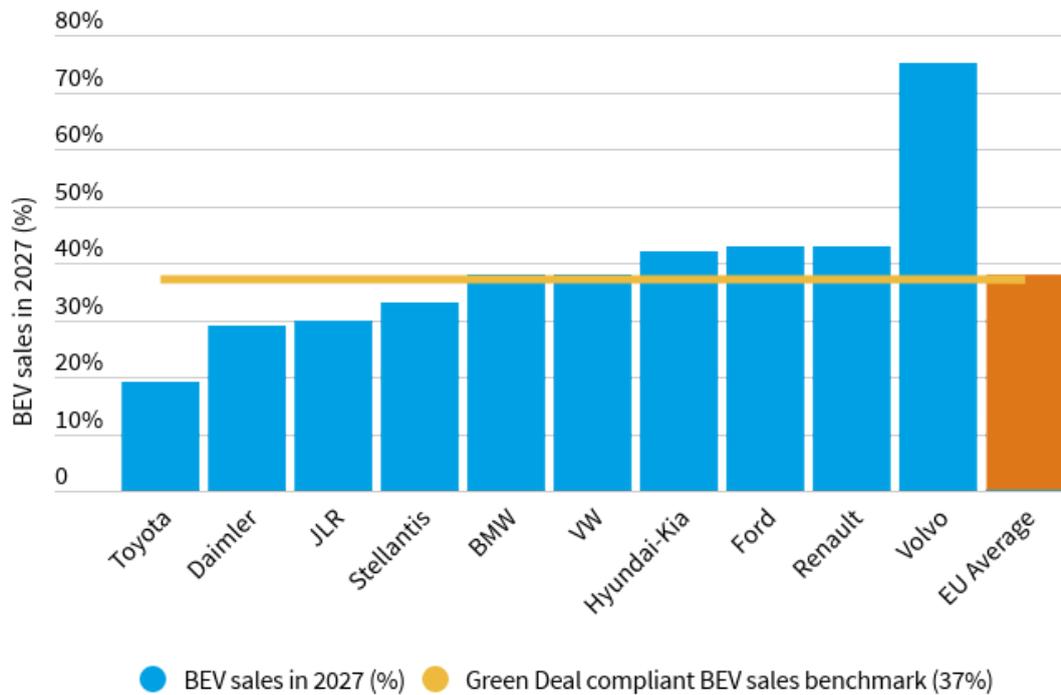
Green Deal compliant trajectory is based on the BloombergNEF study 'Hitting the EV Inflection Point' (May 2021)

Figure 19: assessment of carmakers BEV sales share in 2025 in Europe

2027 BEV share comparison

In 2027, 37% of cars sold need to be fully electric according to a Green Deal compliant scenario. Figure 20 highlights that the expected EU BEV sales of 38% would be consistent with this target. Four carmakers, Volvo with 77%, Renault and Ford with 43% and Hyundai-Kia with 42%, are expected to exceed the Green Deal compliant benchmark while two OEMs (VW and BMW) would fall very close to it. But the remaining carmakers (Stellantis, JLR, Daimler, and Toyota) would not exceed 33% and would fall short of this scenario.

³⁴ Daimler 25% public commitment is in the best case scenario: "Up to 25 percent of unit sales to be accounted for by all-electric vehicles (depending on the framework conditions)" [24]

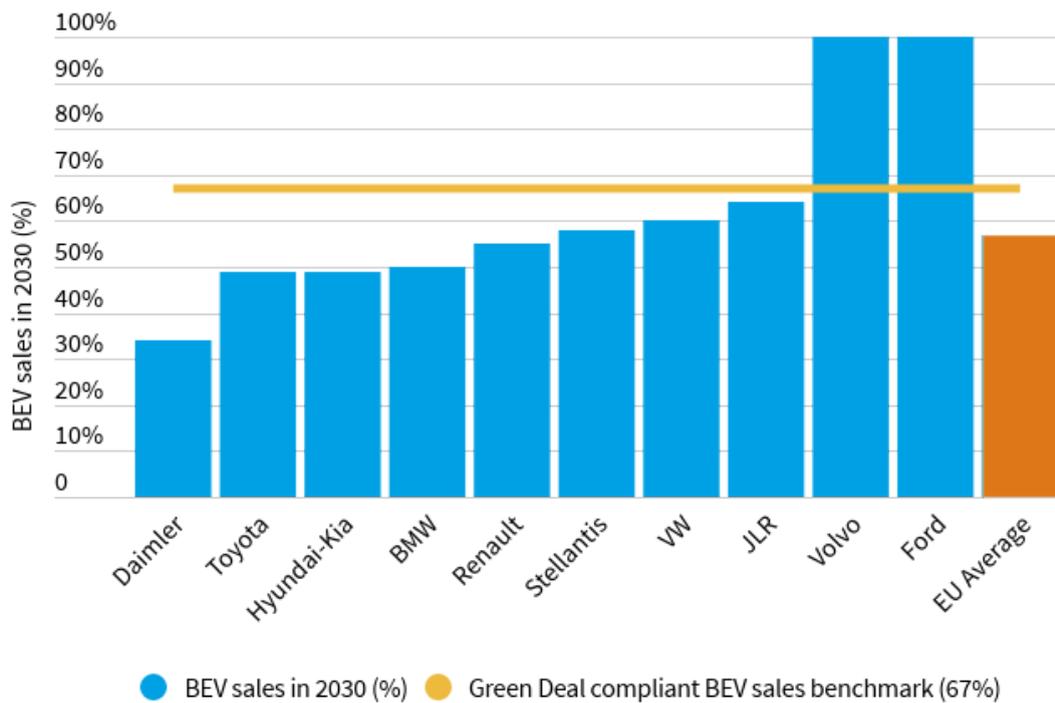


Source: T&E assessment of OEM announcements and modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021
 Green Deal compliant trajectory is based on the BloombergNEF study 'Hitting the EV Inflection Point' (May 2021)

Figure 20: assessment of carmakers BEV sales share in 2027 in Europe

2030 BEV share comparison

In 2030, a Green Deal compliant scenario would require two thirds of the cars sold in Europe to be fully electric. As shown in Figure 21, with only 57% BEV sales expected on average, this target appears to be largely missed even when taking into account carmakers' voluntary commitments. Only the 100% BEV commitments for 2030 from Ford and Volvo are ambitious enough to be compatible with the EU's climate ambitions but they still have to prove that their commitments are backed by strong and concrete strategies. Moreover, given that the 2030 voluntary commitments can still easily be amended, there are still high risks that even a 57% BEV expectation would not be met.



Source: T&E assessment of OEM announcements and modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021
Green Deal compliant trajectory is based on the BloombergNEF study 'Hitting the EV Inflection Point' (May 2021)

Figure 21: assessment of carmakers BEV sales share in 2030 in Europe

4.3. What this means for the EU car CO₂ regulation

4.3.1 A transition based on voluntary plans

Based on the assessment of OEM production plans for the next decade in Europe, T&E has evaluated the level of ambition of the EU car CO₂ reduction targets which corresponds to the expected market evolutions and carmakers' voluntary EV sales targets as shown above.

Current plans could deliver 65%-70% CO₂ reduction in 2030, but remain voluntary

If carmakers hit their own targets, as analysed in this report, the EU could achieve fleet average CO₂ reductions of 30-35% CO₂ reduction in 2025, around 50% in 2027 and 65%-70% in 2030 compared to the 2021 baseline (depending on the level of flexibilities that are used, see Annex 6.10 for assumptions). This is approximately double the current EU targets of 15% reduction from 2025 and 37.5% from 2030, which shows that the ambition can be increased. However, this higher ambition can only be achieved if the EU ensures that voluntary commitments become reality and are backed up by industrial actions.

The transition can't rely on voluntary commitments

Electric car sales forecasts calculated in this report are not set in stone and are subject to change and inherent uncertainties. Many of these announcements and plans -especially those for 2030 and beyond- may be used to impress investors rather than setting an effective transition plan in stone.

History has shown that without strong binding targets, carmakers hold back CO₂ reduction technology and potential to maximise profit - mostly by selling polluting SUVs - to extract as much value as possible from the ageing investments in combustion engines.

- The car industry failed to reach its 1998 voluntary CO₂ commitments back in 2008/9, which is the very reason why we have the mandatory car CO₂ standards today. In 1995, the European Commission adopted a strategy for reducing CO₂ emissions from cars which relied on voluntary commitments from the carmakers. In 1998, the three main automotive associations (the European Car Manufacturers Association (ACEA), Japan Automobile Manufacturers Association (JAMA), and Korean Automobile Manufacturers Association (KAMA)) signed voluntary CO₂ tailpipe emission reduction agreements with the European Commission. These voluntary agreements committed each manufacturer to a target of 140 g/km by 2008 for ACEA and 2009 for KAMA/JAMA. The agreements were designed to reduce CO₂ emissions by 25 percent from 1995, but only two manufacturers met the targets, with average CO₂ emissions at 154 g/km in 2008 and 147 g/km in 2009³⁵. In response, the Commission developed a mandatory CO₂ emission reduction program.
- T&E previously showed that carmakers failed to hit their own goals for sales of electric cars: in 2016, on average, carmakers aimed at selling 3.6% electric cars but only achieved 1.7% [60]. This varied among companies: Volkswagen reached almost 2% EV sales while targeting at 3.5%. BMW sold 4% of EVs and aimed at 10%. Renault-Nissan sold 2.5% aiming at 8%.
- Between 2016 and 2019, official lab emissions increased, from 118 g/km to 122 g/km as carmakers had easily met the weak 2015 target and no annual or intermediate increased targets applied before 2020.

Plus, the stark decrease of the diesel market in Europe following the dieselgate scandal is a stark illustration that unplanned events, changes in strategies or economic downturns could lead carmakers to revise their own targets and reconsider or adapt their plans.

Only when new, more stringent, targets entered into force in 2020 did carmakers bring in new electric car models and actively sold them to reduce their emissions - rather than suppressing and delaying EV sales. This unfortunate experience has taught us that in the absence of increasing targets that go beyond the expected market trends, carmakers will fail to set a rapid decarbonisation trajectory for themselves.

³⁵ Between 1995 and 2008 average emissions from new cars sold in the EU-15 fell by 17.2%, from 186g CO₂/km to 154g CO₂/km. In 2008, only Peugeot and Fiat brands were below 140 g/km (138 g/km). Over the same period new cars sold in the EU became significantly bigger and more powerful.

Stronger car CO₂ reduction targets are needed to set a firm trajectory as well as provide visibility and guarantees about the uptake speed of BEV sales in Europe. This certainty is necessary to provide the direction of travel for the industry as it undergoes steep transformation. It will also ensure that Europe remains the leading EV market globally and thus safeguard the competitiveness of the EU industry.

4.3.2 Pooling and effects on the EU-wide market

The European Commission has hinted in the 2030 Climate Plan from autumn 2020 that it would propose a 50% car CO₂ reduction target for 2030 as part of the 'fit for 55' climate legislative package in July. Not only does such a target fall significantly short of current voluntary targets from the industry, but it also opens the door to a significant delay of the emobility transition as it would not require carmakers to accelerate their BEV investments and would lead them to postpone electrification efforts, notably because of pooling and PHEV strategies, as illustrated with this subsection and the next one.

Thanks to the pooling mechanism, emobility laggards can benefit from the stronger ambition of other players by simply buying CO₂ credits. In practice, this pushes the market average towards doing the very minimum, i.e. landing right on the target. With some carmakers leading the emobility transition and possibly overshooting the target, this would likely have the perverse effect of discouraging any action from other carmakers which are further behind. Carmakers do not have to disclose the value of traded CO₂ credits (decided under a bilateral agreement), which means that under weak CO₂ targets, the likely value of CO₂ credits traded would be low - even possibly below the carmaker's own compliance cost - thus effectively discouraging carmakers from investing in battery electric cars.

VW is expected to be the largest producer of fully electric cars in 2030 (31% of the production in Europe) which means this OEM's strategy will be of pivotal importance for the European market. In this illustrative and hypothetical example, T&E assumes that the German carmaker will deliver on its 60% BEV sales promise and assesses the consequences of large scale pooling between OEMs.

Under a 50% car CO₂ reduction target in 2030, carmakers could comply by delivering 38% BEVs in that year (together with 10% PHEVs) if they all do the minimum to comply with the targets (no pooling). If VW delivers on its 60% target, other carmakers would only need to sell 30% BEVs on average if all market players were to minimise efforts by pooling with the EU's largest BEV producer. This compares with a 53% share of BEV sales according to the production plans and current voluntary commitments. In other words, in this hypothetical scenario, pooling strategies would prevent the production of 2.6 million fully electric cars, more than five times the number of BEV registrations in 2020. Therefore, pooling strategies combined with the inadequate CO₂ targets could jeopardize the achievement of ambitious decarbonation targets.

In short, the EU pooling provisions mean that carmakers that sell more EVs than the regulation requires can simply allow others to sell less and buy credits from them, which means that as a whole the EV market is likely to follow the path of the least resistance or least production costs - i.e. in line with minimum requirements.

When correctly designed, a pooling mechanism can have positive impacts by helping and incentivising new entrants to sell electric cars. However, the automotive industry has asked for a joint pooling system between cars and vans [61] which could lead to some serious unintended consequences where carmakers could prioritise efforts on some segments (e.g. cars) while doing no efforts for others (e.g. vans). To ensure that there is no structural weakening to the car CO₂ regulation, it is essential that the pooling mechanisms for cars and vans are kept separate and that a cap is introduced on the maximum amount of CO₂ fleet average reduction that can be achieved by pooling.

4.3.3 PHEVs

The weaker the CO₂ reduction targets the more flexibility carmakers have to sell PHEVs instead of BEVs to deliver on the target. By slightly increasing the battery size in PHEVs to close to 20 kWh on average in 2030 (from 13 kWh in 2020, according to IHS Markit), PHEVs would be expected to achieve high utility factors under the current WLTP test cycle rules and thus could benefit from generous CO₂ emission values of around 30 g/km in 2030.

Under a hypothetical 2030 CO₂ reduction target of 50%, carmakers could easily favour PHEVs over BEVs, even up to and beyond 2030. Indeed, by prioritizing battery volumes toward making more PHEVs, rather than BEVs, OEMs could comply with the target by selling only 10% BEVs (and close to 40%-50% PHEV), or close to 20% BEV when combined with around 30% PHEVs, or with 24% BEV and 24% PHEV in the situation where the plug-in mix is split evenly between PHEVs and BEVs. Although the future mix between BEVs vs. PHEVs will vary from one carmaker to another, this illustrative example shows that high sales of BEVs are not a given. With PHEV sales surpassing BEV sales in the first quarter of 2021 (+42%) it became clear that it was challenging to make any forecast on the respective role of both technologies. For comparison, under a 65% CO₂ reduction target, a 24% share of PHEV sales would have to be compensated by at least 41% BEVs.

Higher sales of PHEVs in the EV mix than what was found in section 4 of this report (66% of plug-ins in 2025, 75% in 2027 and 82% in 2030) would make the transition costlier and less effective. Indeed, prioritising PHEV sales over BEV sales would increase the cost of new cars as it would mean that carmakers are suppressing the sales of more affordable BEVs or simply have not invested in BEV production sufficiently to bring down the costs. Plus, the regulation would be less effective in bringing down real world CO₂ emissions given that PHEVs have been proven to emit 2-4 times more in the real world than what they are counted for in official test emission values [62].

4.3.4 Tighter and earlier CO₂ reduction targets are needed

T&E has highlighted that regulators cannot rely on voluntary commitments from the industry and that the EU needs to set much tighter CO₂ reduction targets if the regulation is to ensure that current production plans and voluntary targets are achieved. Crucially, early regulatory action (i.e. CO₂ reduction targets for 2025 and 2030) are essential to reach two thirds BEV sales in 2030. Without these more ambitious targets, the EU car CO₂ regulation would be inadequate and would fail to deliver the timely

production scale up. Indeed, under the current car CO₂ targets, BEVs sales in 2025-2029 could be as low as 10%.

Above all, cost reductions depend on volume and early action is key. As highlighted previously, a recent analysis from BloombergNEF [3] and commissioned by T&E has shown that BEV sales need to reach 22% of sales in 2025, 37% in 2027 and 67% in 2030 to put the EU passenger car sector on a trajectory compliant with an ICE-phase out in 2035 and thus compliant with the EU Green Deal ambitions³⁶.

Early regulatory action is necessary to make carmakers mass produce electric cars and unlock the cost reduction potential needed to have electric cars reach purchase price parity with ICEs. Indeed, the BloombergNEF study shows that the cost parity between BEV and ICE would be reached -on average- in 2025 for light vans, in 2026 for sedans, SUVs and heavy vans, and in 2027 for small cars. These dates are based on volume assumptions - as well as battery cost reductions - which can only happen if regulations require carmakers to scale up manufacturing before price parity points in the mid-2020s. Without high volume electric car production, carmakers will not be making the shift to dedicated platforms for example - or at least not as fast. In short, BEV cost reductions will not be reached without early ramp up in production volumes, which itself will not be possible without early regulatory action to drive rapid uptake. Furthermore, an increasing amount of scientific evidence [63] now shows that the policies that give market players the confidence to roll out technologies make the transition cheaper and faster than generally calculated because of the often overlooked effects of inertia, induced innovation, and path dependency.

This shows that the EU vehicle CO₂ regulation is crucial to push carmakers to mass produce EVs: increased car CO₂ targets in 2025, and new targets in 2027, are essential to drive down costs and generate consumer buy-in for further adoption in the future and ultimately to reach 100% BEV sales by 2035 at the latest³⁷.

³⁶ BNEF analysis is based on a comprehensive techno-economic assessment of the production cost of BEV as well as an analysis of policy measures to support BEV uptake in the short and medium term.

³⁷ The BNEF study also shows that BEVs could reach 100% of new sales across the EU by 2035 thanks to these cost reductions granted that lawmakers introduce the right support.

5. Conclusions & recommendations

The forecast of carmakers' plans based on recent IHS Markit production data show that BEVs would account for more than half the European Union (EU27) total car production in 2030. The findings are clear: carmakers' production plans are clearly geared toward the sales of battery electric vehicles in the future. However, the current car CO₂ regulation and the proposals expected from the European Commission this summer fall short of providing the right conditions and guarantees to ensure the timely and optimal transition to an all-electric future. Forecasts or current voluntary commitments on their own provide no certainty that such plans would go through.

Based on carmakers' production plans and voluntary commitments, the market is expected to reach 26% BEV sales in 2025, 38% in 2027 increasing to 57% in 2030. Unsurprisingly, this shows that **the level of ambition of the current EU targets falls short of what the industry plans to deliver by a factor of more than two**. According to these plans, the EU can achieve more than 30% CO₂ reduction in 2025, 50% in 2027 and 70% in 2030, but regulatory action is needed to ensure carmakers follow through on their promises. What the current plans demonstrate is that the car industry can go a lot further than what the current targets require, but such voluntary announcements should also be seen as a way to impress investors and can yet change if more profitable strategies become feasible. Nonetheless, these plans are still largely insufficient to reach the two-thirds in 2030 needed to phase out the ICE sales by 2035 and thus align cars with the European Green Deal ambitions.

No significant volumes of hydrogen or gas cars are planned up to 2030, while the PHEV share is expected to decline after 2025. **BEVs are by far the dominant technology** chosen by carmakers to deliver on the decarbonisation of passenger cars, so the EU should recognise it as such and bring clarity to the current outdated 'technology neutrality' mantra. With BEVs bound to become cheaper than petrol cars in all segments over the period 2026-2027 thanks to plunging battery prices and carmakers switching to dedicated production lines, the direction of travel has never been so clear. Battery electric technology is now not only best for the climate and consumers, it is also good for carmakers' own business.

The EU should therefore revise its car CO₂ standards in line with the BEV potential and rising industry ambitions. It should not look at increasing the 2030 target alone but should, crucially, **increase the targets as of 2025 and set an intermediate target in 2027**. Under the current targets, the minimum required effective CO₂ reduction target could be as low as 2%-6% from 2025 to 2029 thanks to significant weakening from regulatory flexibilities. As a result, carmakers' electric car sales could stagnate at today's levels up to the end of the decade. **Higher targets throughout the 2020s are also key to ensure the necessary cost reductions**. Reaching high BEV volumes in the 2020s is a prerequisite for lower production costs, economies of scale and thus affordable electric cars. Thus, ambitious 2025 and 2027 targets are of paramount importance to bring BEV costs down and deliver on the Green Deal climate ambition.

Given the OEM plans, **setting a target as low as 50% CO₂ reduction in 2030 could delay the BEV transition against its potential**. For example, by choosing to pool with leading carmakers rather than to increase the sales of EVs, BEV sales could be as low as 30% in 2030 across a majority of the carmakers.

Alternatively, thanks to weak targets and their design, carmakers could prioritise PHEV sales over BEV sales and easily suppress the sales of the latter to 10-20%, which would divert from their high-BEV production plans toward sub-optimal PHEV strategies. Not only does a 50% target fall significantly short of current voluntary targets from the industry, but it also opens the door to a large delay of the mobility transition as it would likely lead carmakers to postpone investment into electrification. So, ironically, the very law that gave Europe a head start in mobility now risks bringing delays and a possible demise globally.

Failing to set ambitious targets means that there are no **guarantees** or visibility on the direction of travel of the automotive industry. Voluntary targets can often be used to inflate stock prices and attract investors, but are not set in stone and lack industrial plans, notably battery metals supply, to achieve them. Any type of unplanned event, or economic downturn could lead carmakers to revise and adapt their plans. Forecasts, production plans and voluntary targets analysed in this report have an inherent part of uncertainty. But with an ambitious direction of travel set in the EU regulation, tomorrow's industries like battery producers, e-powertrain suppliers, grid and charging operators will largely benefit by allowing them to plan the transition most effectively. The revision of the EU car CO₂ targets are a once in a lifetime opportunity for the European automotive industry to lead the way globally. Much is at stake: the decarbonisation of the EU passenger car sector, EU's industrial leadership as well as the transition of a key part of our economy and workforce. Such high stakes cannot be left to the hands of voluntary industrial commitments and (mostly) weak industrial transition plans.

Reaching climate neutrality in 2050 is the ultimate goal set in the European Green Deal. For cars and vans, this means **phasing out the sales of all vehicles with a combustion engine by 2035 at the latest** in the EU. Although the trip might bring sweat and tears, the EU has what it takes to make this transition happen and nothing can be ensured without strong political action. With the proposal for the car CO₂ revision expected on July 14th, the European Commission has the chance to make or break the transition to battery electric cars in Europe.

T&E recommends the following for the revision of the EU car CO₂ standards:

- *Increase the EU fleet-wide CO₂ reduction target to at least 25% for 2025, and at least 65% for 2030*
- *In addition to more ambitious 2025 and 2030 CO₂ targets, adding a binding interim target of at least -40% CO₂ reduction in 2027.*
- *Set the EU-wide CO₂ emissions standard at 0 gCO₂/km by 2035 while allowing individual member states to set earlier phase-out dates.*
- *No CO₂ credits to carmakers for alternative or synthetic fuels should be included into the CO₂ standards.*
- *The ZLEV benchmark should be removed as soon as the EU-wide EV market reaches 25%, and no later than 2030. Until then, the 0.7 multiplier from the calculation of ZLEV credits should be removed and PHEVs should meet all of the following criteria to qualify for any ZLEV credits: electric motor power should be equal or more than ICE engine power, at least 80 km real world range, capable of fast charging (50 kW) and the PHEV charge sustaining emissions (engine only*

mode) should be capped at max three times the official CO₂ value (or 150 g/km, whichever is the lowest).

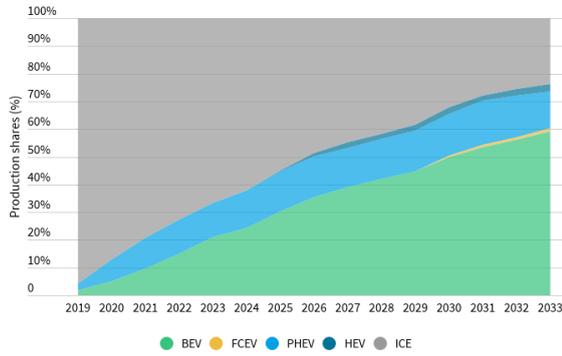
- Real world CO₂ emissions should be used for compliance enforcement with car CO₂ regulations no later than 2025 with target adjustment when growing gaps are detected.
- Remove the mass-adjustment part from the specific emissions reference target formula (effectively setting a_{2025} and a_{2030} at zero) thus requiring all carmakers to achieve the same CO₂ targets regardless of vehicle weight.
- Limit average ICE emissions at 2021 levels by ensuring that the OEM specific ICE-only average CO₂ emissions (including hybrids) do not increase in any year after 2021, even when they claim ZLEV bonuses and sell more EVs.

Beyond the EU car CO₂ targets, the following should be provided:

- The revision of the AFID should set an EU charging masterplan in a new zero emission only regulation which sets binding targets on the number of public chargers to be deployed per Member State.
- Accompanying an ICE phase out, the EU should establish a comprehensive European automotive transition agenda, including a dedicated fund to finance reconversion. This should support the transition towards new industries and skills in those regions where impact will be most acute due to reliance on old economy jobs.
- Use real world fuel consumption and CO₂ data for PHEVs (collected from on-board fuel consumption meters from 2022) to set (and regularly update) real-world utility factors (UF) that should then be used to establish WLTP CO₂ values which are in line with real world use and emissions of PHEVs.

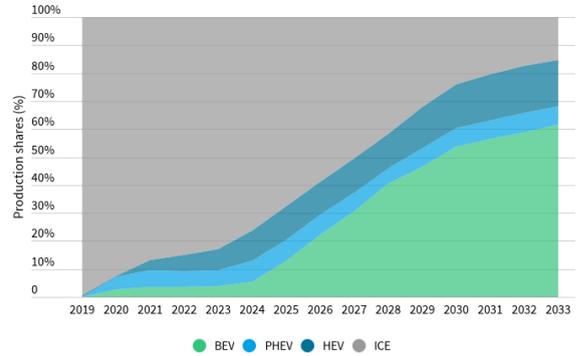
6. Annexes

6.1. Six largest countries production in Europe



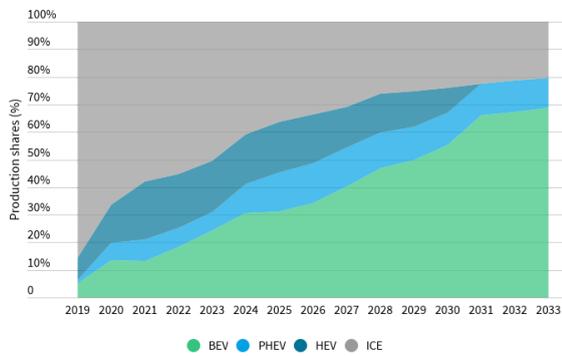
Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Car production in Germany



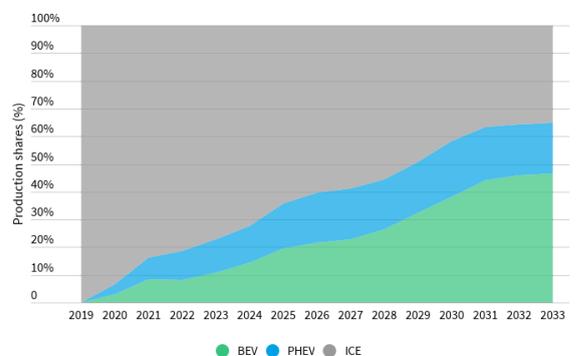
Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Car production in Spain



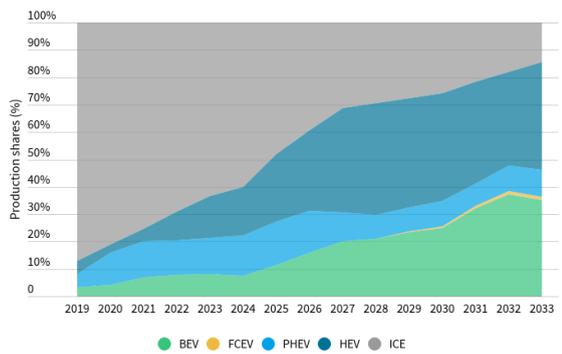
Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Car production in France



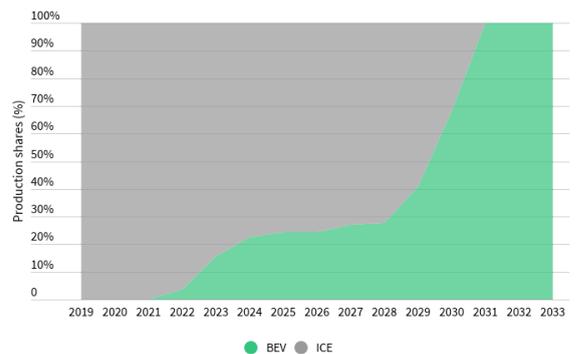
Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Car production in Italy



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Car production in the UK

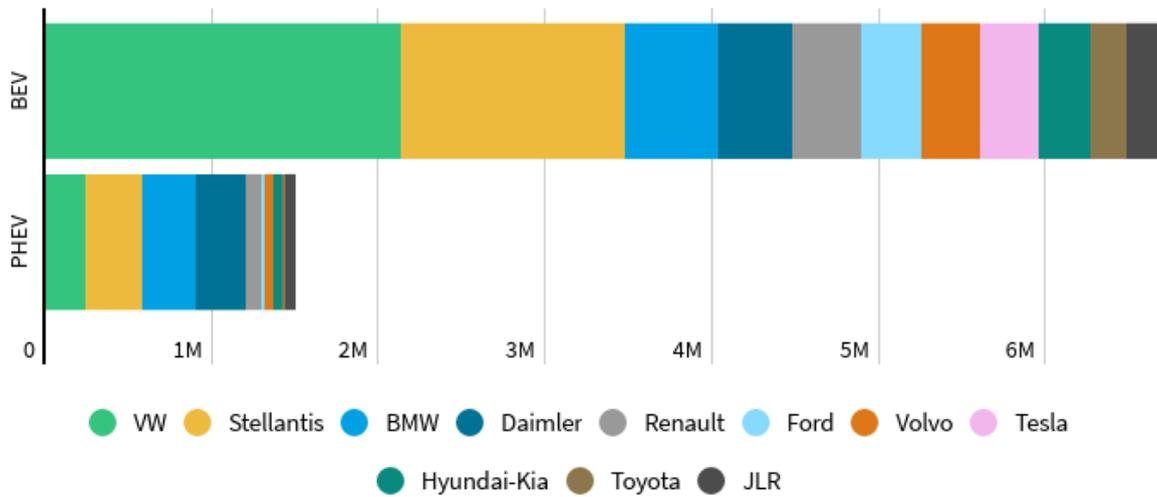


Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Car production in Poland

Figure 22: Car production share by drivetrain in the 6 largest countries in Europe

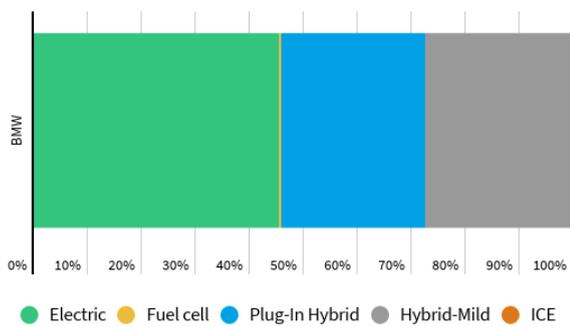
6.2. BEV and PHEV production volumes in 2030



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 23: 2030 EV production volumes in the EU27+UK

6.3. OEM detailed 2030 production plans



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 24: BMW 2030 EU production shares

BMW EU BEV production is expected to be close to 50% in 2030. But the OEM is also the one with the largest PHEV production share (more than a fourth). Mild hybrids also reach more than a fourth of the production. The carmaker is among the first to produce fuel cell cars in Europe from 2027 and its production is expected to remain low with around 4 thousand units in 2030. BMW is expected to be ranked at the third position in terms of BEV production volume and is tied with Stellantis at the first position in terms of PHEV production volume.

Daimler is ranked at the fourth position in EU BEV production volume but is still among the laggards regarding its BEV share that would barely reach the third of its production. The OEM is expected to produce more ICE (Mild Hybrid) in 2030 than BEV and also include a large part of PHEV (nearly the fourth) in its production mix. Its PHEVs are expected to have the longest range but its electric motors are still expected to be largely less powerful than the ICE. Daimler FCEV production initially planned is most likely cancelled Daimler have since discontinued their fuel cell development [7].

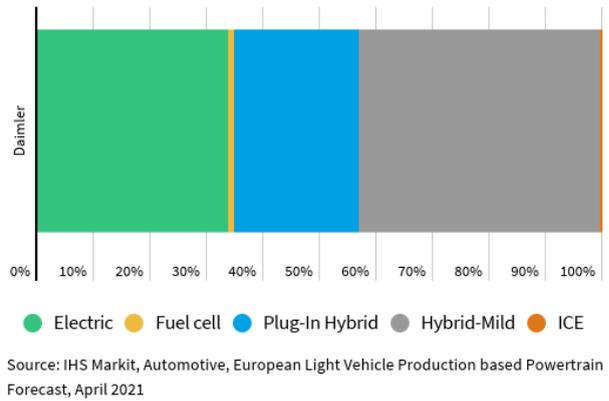


Figure 25: Daimler 2030 EU production shares

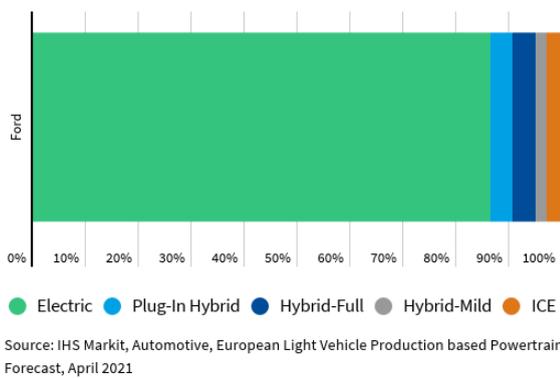


Figure 26: Ford 2030 EU production shares

Ford is targeting very high levels of BEV production share in 2030 with nearly 90% of its EU production mix. But the carmaker is expected to produce only a limited number of cars in Europe. Ford BEV production should account for only 2% of EU BEV production. According to IHS Markit forecast, other fuel types are marginally included in its 2030 EU production plans but they are expected to be dedicated to exports as the OEM plans to become an all-electric brand [21]. Depending on the actual implementation of the OEM's commitment, the BEV share in its production mix could increase to 100%.

Hyundai-Kia is expected to have a BEV production share aligned with the EU average. The South Korean carmaker should only reach 5% of the total EU electric car production. Its production mix is diversified but it should still rely substantially on ICE as Mild Hybrid and ICE amounts to around a third of its production. Hyundai PHEVs produced in the EU in 2030 are classified among the PHEV with low power and low range. As the carmaker is importing a large part of its sales from outside the EU, its actual 2030 sales mix may differ significantly from its forecasted EU production.

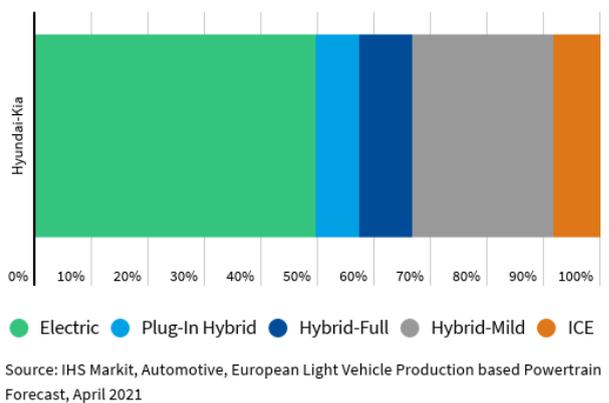
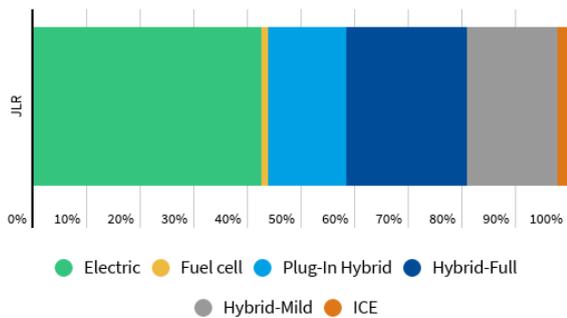


Figure 27: Hyundai-Kia 2030 EU production shares

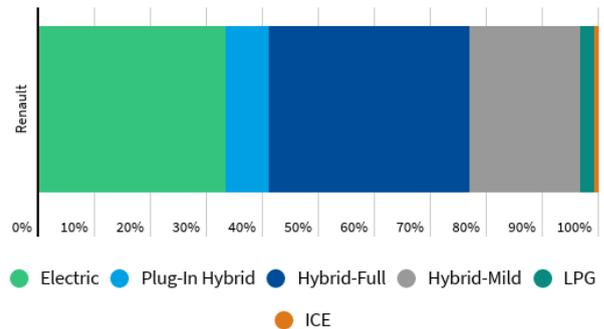


Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 28: JLR 2030 EU production shares

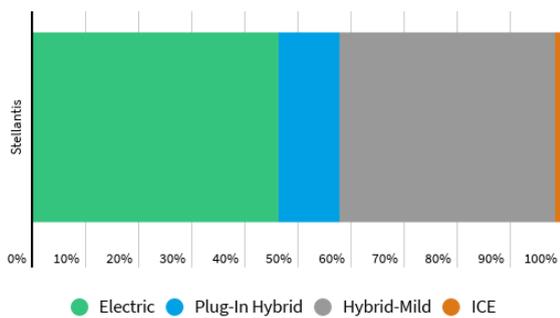
JLR is the carmaker expected to produce the lowest volume of BEV in Europe and its BEV amounts to slightly more than 40% of its production. As the carmaker is expected to export several models, its 2030 BEV sales might improve compared to the forecasted production. The British carmaker is expected to start a low scale Fuel Cell vehicle production in 2029.

Renault EU production plans as of April 2021 according to IHS Markit were the following: the OEM was targeting more than a third HEV and only a third BEV production in 2030. The carmaker was also expected to be the last one still producing LPG cars with around 30,000 units produced in 2030. Nevertheless, its recent strategy includes a target of 90% plug-in sales share (both BEV and PHEV) for the Renault brand [2] which significantly differs compared to previous IHS Markit EU production plans. From an initial high share of HEV, Renault is expected to switch to a minimum HEV share below 10%. Consequently Renault’s BEV and PHEV EU production plans are expected to be higher than what is presented here.



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 29: Renault 2030 EU production shares

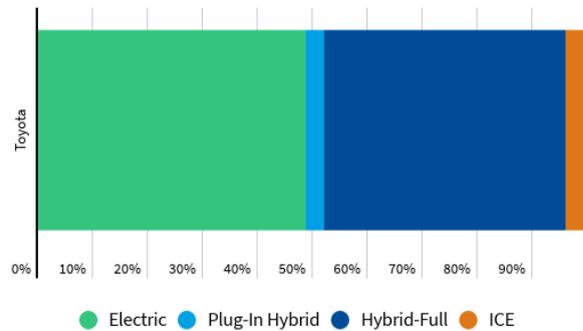


Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 30: Stellantis 2030 EU production shares

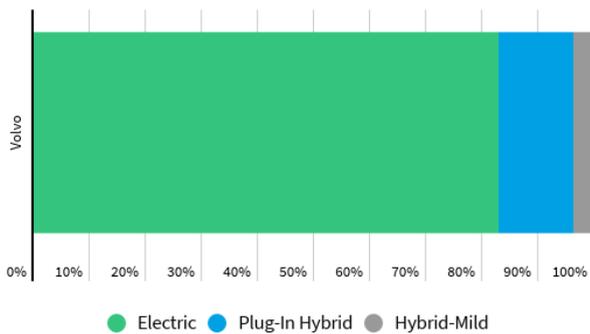
Stellantis is expected to be the second largest producer of electric cars in Europe but the BEV share of its production mix would remain limited below 50%. Having some plants in countries close to the EU and with export of ICE versions, the OEM 2030 BEV sales might improve compared to the expected EU production. With more than 40% of the EU production mix, the ICE Mild Hybrid technology should be the option widely used by the carmaker after the full electrification. The OEM recently announced that Fiat is committed to become an all-electric brand in 2030 [58] and this could increase the BEV EU production share to around 52%.

Toyota is producing quite a low volume of cars in Europe and its fully electric cars would be limited to only 3% of the whole EU BEV production. With a share just below 50% BEV in its expected EU production mix, the Japanese OEM is aligned with the European average. With a large amount of cars imported from outside the EU, the sales values could differ from the expected EU production. Toyota is the OEM that relies the most on the Full Hybrid technology.



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 31: Toyota 2030 EU production shares

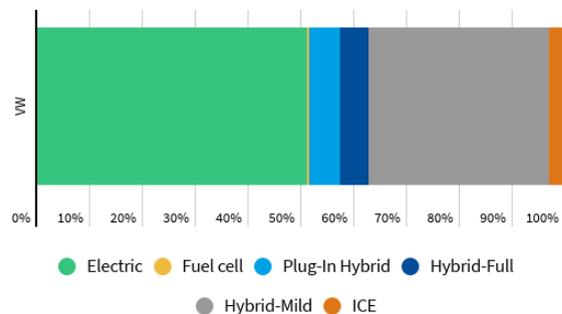


Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 32: Volvo 2030 EU production shares

Volvo is aiming for a very large part (more than 80%) of its EU production to be fully electric in 2030 but the Swedish carmaker is among the OEM having a low share of the EU BEV production in volumes. The current IHS Markit EU production forecast includes some PHEVs and ICEs in the EU production mix of Volvo whereas the OEM plans to become an all-electric brand [10]. Therefore, the BEV share in its production mix could increase to 100% depending on the actual implementation of the OEM's commitment and its export strategy.

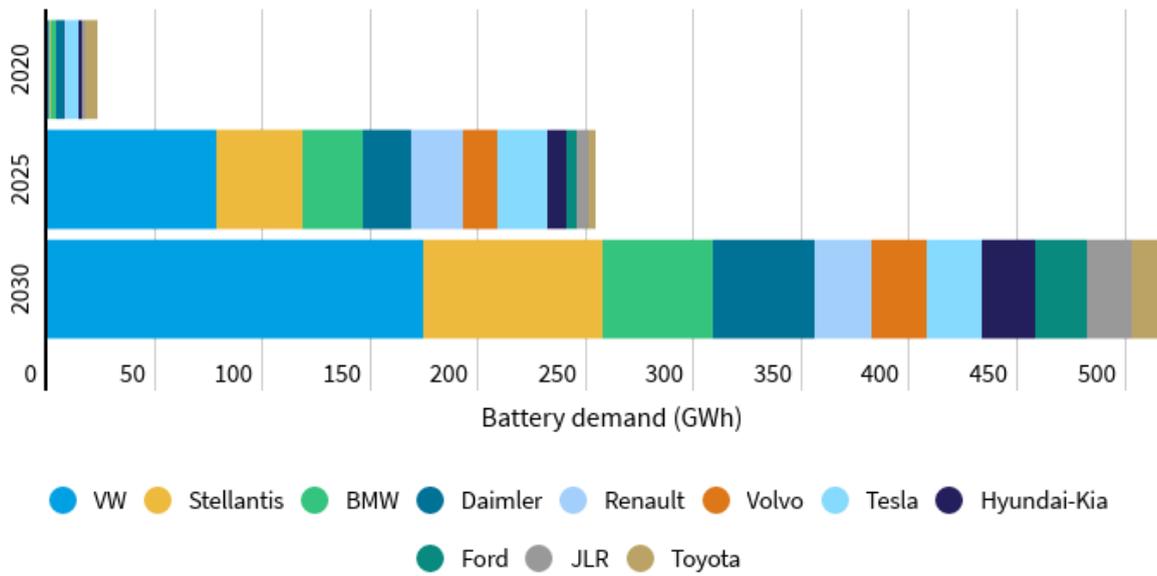
VW is expected to be the leader in terms of BEV production volume in Europe. Its forecasted production plan included more than half fully electric cars in 2030. But the share of BEV in its 2030 sales could be higher if the OEM exports enough ICEs. VW PHEVs are among the less underperforming and might provide nearly decent specifications. Still, the carmaker is expected to keep a large part of its production dedicated to ICE in Mild Hybrid configuration. VW initially planned to include FCEV in its EU production mix but recent updates of its strategy show that this production is expected to be cancelled [8].



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 33: VW 2030 EU production shares

6.4. OEM battery demands



Source: IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 34: Battery demands in 2020, 2025 and 2030 from OEMs' European production

6.5. T&E EV readiness index details

The T&E EV readiness index is based both on information publicly available (OEM websites, press releases, news websites, etc.) and data extracted from the analysis of IHS Markit's light vehicle EU production forecast. T&E's team carried out an extensive research up to early June 2021, later announcements are not included in the ranking. Despite research that was meant to be extensive, it is possible that details of OEMs strategies were missed where they are not publicly available. If serious mistakes are found, please get in touch and T&E would be eager to learn and update the current or future rankings where appropriate.

T&E's EV Readiness Index has two components:

1. Ambition on BEV share of sales out of 50 points: 10 points for 2020 EU BEV sales, 15 points for 2025 EU production plans and 25 points for 2030 EU BEV sales ambition.
2. Industrial strategy to back up the above ambition, also out of 50 points. 20 points are given for the expected use of in-house dedicated BEV platforms (in 2020, 2025 and 2030), 20 points for the battery strategy (chiefly with regards to battery cell manufacturing) and 10 points for charging partnerships.

In an attempt to be comprehensive, this index grants points for both early action and plans as well as longer term commitments. Given that plans in the next five years are more reliable than longer term commitments, that early actions should be preferred over long term targets and that they give a clearer indication of an OEM's intentions, it is justifiable to give points for early action.

6.5.1. BEV ambition (50 points)

The BEV ambition score is a rating over 50 points defined according to 3 sub-criteria to assess both short and long term BEV ambitions of each OEM:

- The 2020 BEV sales (10 points) rewards carmakers that had an early BEV strategy. The rating is proportional to the EU BEV sales share in 2020 according to Dataforce market data (passenger vehicles sales in 17 countries which cover 95% of the European market). The rating is scaled so that a 11% BEV share in 2020 (the maximum share amongst the ten carmakers analysed, i.e. Hyundai-Kia) is awarded 10 points, a 0% share has zero points and the other ratings are linearly interpolated.
- The 2025 BEV ambition (15 points) is based on OEM EU BEV production shares according to the IHS Markit forecast database. It rewards OEMs that are expected to quickly ramp-up their BEV production in Europe. 15 points are awarded for a 57% EU BEV forecasted production in 2025 (the maximum production share amongst the ten carmakers analysed, i.e. Volvo cars) and lower production are scaled linearly (down to zero points if no BEV production).
- The 2030 BEV ambition (25 points) is proportional to the estimated 2030 BEV sales share (see section 4.1). A 100% BEV sales commitment gives 25 points and lower shares are proportional.

Table 3: BEV ambition ranking

OEM group	2020 EU BEV sales share (%)	Current BEV sales (/10)	2025 EU BEV production share (%) (car data from IHS Markit)	2025 BEV ambition (/15)	2030 EU BEV sales share (%)	2030 BEV ambition (/25)	BEV ambition (Total score /50)
Volvo Cars	1	1	57	15	100*	25	41
Renault	9	8	35	9	55**	14	31
Ford	0	0	13	3	100*	25	28
Hyundai-Kia	11	10	18	5	49	12	27
JLR	8	7	11	3	64**	16	26
VW	5	5	21	6	60*	15	25
BMW	4	4	25	7	50*	13	23
Stellantis	3	3	19	5	58**	15	22
Daimler	5	5	16	4	34	9	17
Toyota	0	0	7	2	49	12	14

* OEM public BEV commitment

** Derived from OEM public commitment (brands commitments or BEV+PHEV targets)

Note: 2030 sales targets are defined with the following hypotheses:

- Volvo [10], Ford [21], VW [12], BMW [27] BEV shares are based on OEMs public announcements without further assumptions. It should be noted that the VW brand target is 70% [64] whereas the VW Group target used here is 60%.
- JLR 2030 BEV sales target is based on a 100% target for Jaguar and 60% target for Land Rover [29]. The ratio between the brands is assumed to be the same as the EU production forecast from IHS Markit EU production database.
- The Renault brand targets 90% “electrified” vehicles in 2030 which covers both BEVs and PHEVs [2] (the OEM confirmed to T&E that HEVs are not included in the 90%). The BEV/PHEV ratio is assumed to be the same as in the IHS Markit production forecast for 2030. Regarding the Dacia brand, two thirds of Dacia Spring produced in China are assumed to be dedicated to the EU market. The Alpine brand is expected to be 100% electric. The share of sales between brands is derived from import hypotheses and the EU production share forecasted by IHS Markit.
- Stellantis targets 70% “electrified” sales which includes both BEV and PHEV [57]. The BEV/PHEV ratio is calculated from the IHS Markit EU production forecast with additional information: the Fiat brand is expected to become 100% electric in 2030 [58] and two thirds of some models produced in near EU countries are assumed to be imported in Europe (the Fiat Panda produced in Serbia, the Fiat Tipo and a new model produced in Turkey and the Peugeot e208 produced in Morocco).

- Daimler targets 50% “electrified” vehicles including BEV and PHEV [24] but this EV share target is already met with the EU production alone. Therefore, the BEV share in the EU production derived from the IHS Markit EU production forecast is used (an equivalent BEV target calculated using the electrified target and the forecasted share of BEV and PHEV would lead to a target lower than the BEV EU production share forecasted by IHS Markit). No hypotheses were made regarding the balance of imports and exports of Daimler as the OEM is expected to produce some BEV and PHEV models only in Europe and some other models only in the US.
- As Hyundai-Kia and Toyota do not have public European targets for 2030, the BEV share from the production data from the IHS Markit EU production forecast is used.

6.5.2. Industrial Transition Commitments (50 points)

The Industrial Transition Commitment is a rating over 50 points that are given according to three main criteria. Each rating is based on a qualitative assessment of the OEMs current and future strategies. Vertical integration is favoured as it reflects serious and long-lasting commitments and is a sign of early and ambitious strategic shift towards BEVs.

Dedicated BEV platforms (20 points)

The concept of BEV dedicated platforms is important for the industrial transition for many reasons. First, by using a platform dedicated to fully electric cars, a carmaker can reduce the production cost of its BEV. Technically, it allows optimizing the mass and the whole architecture. For instance, a carmaker that uses a BEV dedicated platform does not need to reserve space for the exhaust line route under the car, and can use an optimized flat “skateboard” architecture that also enables a lower centre of gravity. Moreover, the mechanical constraints in terms of supports and vibrations are quite different between an e-motor and an ICE, allowing a globally lighter architecture when the platform is used only in all-electric configuration. Finally, OEMs such as Tesla intend to use the battery pack as a structural part of the platform, unlocking future mass reduction.

BEV dedicated platforms are a key requirement to optimize cost, efficiency, mass, systems packaging and the overall performance of electric vehicles. For this reason, only platforms that are dedicated to BEVs are considered for this ranking. Multi-energy platforms (which are also used for ICEs and PHEVs) or BEV platforms derived from ICE platforms are not taken into account in the rating as they offer lower cost and technology benefits than 100% dedicated platforms. Nonetheless, the exact technology scope of platforms in 2030 is sometimes unclear as some OEMs give contradictory information. Some carmakers refer to BEV dedicated platforms as “electric first”, “designed for BEV” or “BEV-focused” while, at the same time, they mention that these platforms could be used for PHEVs.

In the T&E EV readiness index, 20 points are given to carmakers committed to use dedicated BEV platforms. The rating takes into account the platforms used across the decade: 4 points for the platforms

used in 2020, 10 points depending on the use in 2025 and 6 points according to the status in 2030. More points are given for short term implementation of the platform strategy because the early use of BEV dedicated platforms is a key driver of the future ramp-up of BEV production and enable cost competitive BEVs. The share of BEVs expected to be produced on the platform is calculated based on the understanding of OEM platform strategies (detailed below) and the IHS Markit EU production forecast. Each rating is proportional to the maximum use of platforms: in 2020, 4 points (out of 4) for 50% BEVs on a dedicated platform (lower value scaled linearly), and in 2025 and 2030 the maximum score is granted for 100% BEVs on dedicated platforms. In addition, two rules are included. First, platforms designed for BEVs on which PHEVs can be produced earn a lower score than 100% BEV platforms in 2030 and the score is thus limited to 4 points out of 6 for all OEMs lacking clarity on the true technical and industrial nature of their platforms (Daimler, Stellantis and JLR). Second, OEMs that are expected to “lease” a BEV platform designed by a competitor get a lower score. In the case of Ford, 4 points are nonetheless given in 2030 as the OEM would have the choice to use its own platforms designed for the US market which is due in the second part of the decade.

Table 4: BEV dedicated platform ranking

OEM	EV Platforms	2020 platform (/4)	2025 platform (/10)	2030 platform (/6)	BEV Platform (Total score /20)
VW	2020: MEB 2022: PPE 2026: SSP	4	10	6	20
Hyundai-Kia	2021: E-GMP	0	10	6	16
Toyota	2022: e-TNGA	0	10	6	16
Volvo Cars	2025: SEA & SPA 2	0	6	6	12
Daimler	2021: EVA2 (BEV) 2025: MMA (BEV+PHEV)	0	5	4*	9
Renault	2021-22: CMF-EV	0	5	3	8
Stellantis	2024: STLA Medium/Large/Frame (BEV+PHEV) 2026: STLA Small (BEV)	1	1	4*	6
JLR	2025: Land Rover EMA (BEV+PHEV) 2026: Jaguar BEV	0	0	4*	4
Ford	2023: MEB from VW	0	0**	4**	4
BMW	2024: Neue Klasse (Multi-energy)	0	0	0	0

* Score limited due to the use of a BEV-focused platform which can also be used to produce PHEVs (not 100% BEV dedicated)

** Leasing a platform from a competitor is not rewarded in this ranking

Since 2020 and the launch of the ID.3, **VW** is the first major traditional carmaker to use a comprehensive BEV dedicated platform. The Modular Electric Toolkit (MEB [14]) was developed as the base for a large range of models from compact cars to large minivans, except premium models that will be based on the Premium Platform Electric (PPE [15]) architecture. Nevertheless, a new platform is currently developed and should be common to all future BEVs. The Scalable System Platform (SSP [65]) is expected to be introduced in 2024 alongside a new generation battery that comes standard on 80% of electric models. In 2020, around half of the group BEVs were produced on a dedicated platform while 100% are expected for 2025 and 2030.

Hyundai-Kia developed the Electric Global Modular Platform (E-GMP [20]) that is expected to be used for all its BEVs from 2021 with the launch of the Hyundai Ioniq 5 nameplate. The EV dedicated platform should be used across all passenger vehicle segments, such as sedans, SUVs and CUVs.

Toyota is expected to start the production of its first all-electric platform, the "e-TNGA", in 2022 with the launch of the Toyota bZ4X SUV [45]. The platform is developed jointly by Toyota and Subaru and will be used for all mid-size and large passenger vehicles.

Volvo is expected to be using 2 main platforms in the future: the second-generation Scalable Product Architecture (SPA 2) that is expected to be used with a floor dedicated to BEV completely different from the PHEV version (the BEV platform will be produced on a separated production line in parallel of the PHEV platform [11]). Then, the new pure-electric platform developed by the Swedish brand's owner, Geely, is expected to be used later in the decade with the launch of the XC20 small SUV [66]. Around 60% BEV are expected to be produced on a dedicated platform in 2025 while 100% are assumed for 2030.

Daimler is expected to use the EVA2 all-electric platform [25] from 2021 for its executive and luxury class BEV (estimated to around half of BEV produced in 2025 in Europe). The German manufacturer is also expected to use the MMA platform for its compact and middle class vehicles from 2025. The OEM presented this MMA platform as an "electric first skateboard" platform designed for BEVs but also indicated that it could be used with body variants for PHEVs [39]. No precise information was revealed on the exact nature of this modular strategy, for this reason the rating is limited to 4 out of 6 in 2030.

Renault is planning to use the CMF-EV platform of the Renault-Nissan-Mitsubishi Alliance in 2021-2022 with the launch of a new urban SUV [41]. The platform will be first launched by the Nissan Ariya model. The platform is expected to be used on the larger cars of the group and smaller compact cars, such as the new R5, are expected to be produced on the CMF-B platform adapted to BEV models [67]. For this reason, it was assumed that only half of the Renault group will be produced in Europe on the CMF-EV platforms in 2025 and 2030 while the other half is expected to be used on the platform derived from the ICE CMF-B platform. Moreover, the Alpine brand of the group is planning to use the lightweight electric vehicle architecture (LEVA) developed with Lotus.

Ford is planning to produce 100% of its BEV on an electric platform in 2030 but the OEM is expected to rely mainly on the VW MEB platform that will be used from 2023 [22]. Ford recently announced the development of two new platforms, one for pickups and the other for compact cars and small SUVs. These platforms are expected to be predominantly used in the US market in the second part of the

decade [48]. But, given the uncertainty and the choice that Ford would have, some points are awarded in 2030 to account for the OEM investment in these dedicated platform developments.

Stellantis has the most unclear strategy. The latest announcements presented 4 “BEV focused” platforms (STLA Small, Medium, Large and Frame [43]) that are expected to be launched from 2024. Nevertheless, the group included the mention of the e-DCT electrified transmission in these platforms, probably meaning that they will be used for PHEVs. One of these platforms (most probably the STLA Medium [68]) should be the PSA eVMP platform that was already planned to be adapted to both BEVs and PHEVs [69]. Finally, IHS Markit forecast database shows that only the smaller segments would not have PHEV versions, meaning that the STLA Small platform is likely to be a BEV dedicated platform without PHEVs. This could be coherent with the planned date of the platform which is later in 2026, as the e-CMP 2nd generation expected end of 2022 is still expected to accommodate mild-hybrids. Given the uncertain nature of these platforms, the 2030 rating is limited to 4 out of 6. In 2020 and 2025, some BEVs are assumed to be produced on a dedicated platform as the Fiat 500e is produced on a new standalone BEV-dedicated platform [70].

JLR is planning a BEV dedicated platform for its Jaguar brand from 2026 while Land Rover models are expected to be produced on the EMA platform. Nevertheless, the OEM also lacks clarity on the design of the EMA platform that could also be used for PHEVs [49] and its 2030 rating is limited to 4 out of 6.

Finally, **BMW** is developing its future Neue Klasse platform for BEV, but ICEs, hybrids, and FCEV powertrains are also expected to be fitted into the new platform [28], implying that the OEM will have no BEV produced under a true dedicated platform in 2030.

Battery strategy (20 points)

The battery strategy rating is composed of four sub-criteria: the battery manufacturing strategy (12 points), the material supply rating (3 points), the battery recycling rating (3 points) and the battery innovation (2 points). This category rewards OEMs with a comprehensive and long-term battery strategy which secures battery packs, cells and materials supply, takes into account the second life and recycling of batteries, and includes efforts in battery R&D. In this category, all criteria are qualitative ratings based on the understanding of the ambition of strategies and their timelines as early actions are required.

Table 5: Battery strategy rating

OEM	Battery Manufacturing (/12)	Materials Supply (/3)	Battery Recycling (/3)	Battery Innovation (/2)	Battery Strategy (Total score /20)
VW	10	3	3	2	18
BMW	7	3	3	2	15
Daimler	6	3	3	2	14
Volvo Cars	7	3	3	1	14
Renault	6	2	3	1	12
Stellantis	9	1	1	1	12
Ford	5	2.5	2	2	11.5
JLR	4	1	2	2	9
Hyundai-Kia	4	0	1	1	6
Toyota	2	0	1	1	4

Battery manufacturing (12 points)

12 points are given according to the OEM European battery manufacturing strategy in the 2020s. This criterion is taking into account in-house cell manufacturing and joint ventures, battery pack assembly lines, or partnership with suppliers having battery production in Europe. For instance, a carmaker that has only one supplier with a gigafactory in Europe and no in-house assembly line would have the minimum points, whereas an OEM having its own cell production capacity, its own assembly lines, investments in a joint venture, and several other suppliers with gigafactories in Europe would have the maximum rating.

This rating is qualitative and based on the following principles: an OEM with an ambitious battery strategy needs to secure its battery supply so that it can match its demand. Even if a wide range of suppliers is important to ensure the resilience and diversification of the supply, most points are given to vertical integration and in-house cell production as it requires a higher commitment and investment from the OEM. The battery module and pack manufacturing are important but the focus is made on battery cells manufacturing as it is the most complex and capital intensive process.

The scores are attributed based on the following order: the highest score is granted for in-house cell production, then for the set-up of a joint venture with a battery cell supplier, followed by direct investment to support a battery cell supplier, long term partnership with a cell supplier, contracts with suppliers without public long-term partnerships and finally (lowest score) in-house module and packs production. Moreover, partnerships with suppliers based in Europe are given a higher score since they are deemed more beneficial as it shortens logistic flows and allows to benefit from the cleaner European electric grid.

Table 6: Battery manufacturing rating

OEM	Battery Manufacturing (/12)
VW	10
Stellantis	9
BMW	7
Volvo Cars	7
Daimler	6
Renault	6
Ford	5
JLR	4
Hyundai-Kia	4
Toyota	2

VW is expected to become the clear leader regarding battery manufacturing in Europe. With six planned gigafactories in Europe amounting to 240 GWh [13], the German OEM is expected to have enough battery supply in Europe for its production. VW battery cell supply will be distributed among its in-house battery cell plant in Salzgitter (Germany) [32] and Porsche specific high performance cell production in Tübingen (Germany) [33], its investments to support Northvolt production [34], and future in-house plans or partnerships that were not revealed yet. Furthermore, LG Chem, Samsung and SK Innovation are current strategic suppliers of the German group, while CATL could be able to provide the new prismatic cell format. All potential partners are already building gigafactories in Europe. The last details of the six gigafactories plan are expected in the near future and they could allow the OEM to earn the maximum score in this category if the detailed plan matches its ambition.

Stellantis invested in the joint venture Automotive Cells Company (ACC [23]) alongside Total and its subsidiary Saft. The French JV has plans for 2 gigafactories, one near Douvrin in France and the other in Kaiserslautern in Germany. Moreover, Stellantis is currently planning a new battery cell project in Italy but details are not yet available. These factories would allow Stellantis to secure a 50GWh cell production in 2030. Moreover, the group is planning battery pack assembly lines in Slovakia, Spain and Italy. The group suppliers include Svolt with production in Germany, LG Chem in Poland and CATL.

BMW invested to support the battery cell supplier Northvolt [44] while its suppliers CATL will produce units in Germany and Samsung batteries are made in Hungary. The OEM is also expected to own three battery module assembly lines in Germany (Leipzig, Regensburg and Dingolfing).

Volvo is also expected to benefit from the investments of its parent company Geely that have a joint venture with Farasis [36]. Moreover, it also has a long term partnership with CATL and LG Chem while the Swedish carmaker assembles its battery packs in Ghent (Belgium).

Daimler has no joint venture for cell production but could rely on four suppliers with gigafactories planned in Europe: CATL, Farasis, SK Innovation and LG Chem. Regarding the battery assembly, the German OEM has plans for six assembly lines with its Accumotive subsidiary [26].

Renault is expected to rely on the Renault-Nissan-Mitsubishi alliance and its investment in Envision AESC (partly owned by Nissan) that plans new battery cell factories in Sunderland (UK) [17] and Douai (France) [18]. It also relies on LG Chem and CATL for its cell supply. The French company is also expected to assemble its battery packs in Douai (France), with Nissan in Sunderland (UK) and at Cacia (Portugal).

Ford recently announced a joint venture named BlueOvalSK [46] with SK Innovation in the US but the OEM appears to be late in the set-up of a comprehensive and secure battery supply. Its strategy about Europe is not known but SK Innovation and its other suppliers such as LG Chem, Samsung SDI have production plans in Europe.

JLR may rely on cells produced by LG Chem in Poland while its batteries are assembled in Hams Hall (UK). The OEM appears to be lacking consistent investments in cell manufacturing which can be explained by the small scale of its business.

Hyundai-Kia uses cells produced by SK Innovation in Hungary or LG Chem and CATL. And the battery assembly process is expected to be done in Czech Republic. No ambitious investments or in-house plans are advertised by the OEM.

Toyota does not appear to have a strategy for battery manufacturing in Europe. Globally, it has a joint venture with Panasonic [71] in Japan but no information was found on its European supply.

Battery material supply (3 points)

This sub-criterion assesses OEMs strategies regarding the supply of critical battery materials such as lithium, nickel or cobalt. A good strategy would be to secure long-term supply of battery materials, to commit to and demonstrate the ethical sourcing of raw materials including due-diligence and use advanced traceability measures such as blockchain technologies.

Table 7: Battery material supply rating

OEM	Materials Supply (/3)
VW	3
BMW	3
Daimler	3
Volvo Cars	3
Ford	2.5
Renault	2
Stellantis	1
JLR	1
Hyundai-Kia	0
Toyota	0

VW has a long-term partnership to source lithium from Ganfeng and cobalt from CATL, via Glencore in the Democratic Republic of Congo (DRC). Most recently, VW announced the launch of the “Responsible Lithium Partnership”, which aims at sustainably sourcing the raw material from Chile [72]. Besides being part of a certification system for cobalt smelters under the Responsible Minerals Initiative, VW is also part of the “Cobalt for Development Initiative”. Regarding traceability, the German carmaker is part of the Responsible Sourcing Blockchain Network and has a partnership to use blockchain with Minespider.

BMW is directly sourcing critical raw materials from mining companies: lithium comes from Australian mines and from its partnership with Livent in Argentina [73], cobalt from Moroccan mining company Managem Group as well as Australia [74]. BMW is also part of the PartChain Blockchain project that expects complete traceability from mine to smelter. Additionally, BMW recently joined the Initiative for Responsible Mining Assurance (IRMA), a multi-stakeholder led organization that offers independent verification and certification of mines against a comprehensive standard.

Daimler is sourcing lithium from Australia and South America. Daimler recently announced that it is also joining the “Responsible Lithium Partnership”, together with VW and others. In the context of cobalt, the company has different partnerships to secure the supply of the raw material. It is part of a blockchain project with the start-up Circulor. It is a member of both IRMA and of the Responsible Minerals Initiative.

Volvo is a member of different initiatives such as the Responsible Minerals Initiative or the Better Mining collaboration that aims to improve the working conditions on artisanal and small-scale mining sites. The Swedish carmaker is using blockchain technology from Circulor and Oracle to track cobalt supply as well as increasing traceability of all raw materials.

Ford is a member of IRMA as well as of the Responsible Minerals Initiative and uses IBM Blockchain to track cobalt under the Responsible Sourcing Blockchain Network. Little is known about its sourcing strategy.

Renault is committed to the ethical sourcing of materials with its responsible purchasing initiative. It includes a policy regarding the responsible procurement of cobalt with a precise supply-chain mapping and audits at each level of the supply chain, leading back as far as small-scale mines.

Stellantis has no clear partnership as a group but FCA was part of the Responsible Sourcing Blockchain Network to trace cobalt using the IBM Blockchain technology.

JLR invested in the start-up Circular that develops a blockchain technology for sustainable materials sourcing but does not specify when the technology will be used.

Toyota appears to be part of the Responsible Minerals Initiative but no details are available on its strategy.

Hyundai-Kia does not appear to have any sourcing strategy on battery metals publicly available.

Battery recycling (3 points)

Three points are allocated to battery recycling according to the partnership or in-house process for recycling, the second life applications expected for used batteries, and the commitment to recycle all batteries.

Table 8: Battery recycling rating

OEM	Battery Recycling (/3)
VW	3
Renault	3
Volvo Cars	3
Daimler	3
BMW	3
Ford	2
JLR	2
Stellantis	1
Hyundai-Kia	1
Toyota	1

VW is well positioned in this category as the company has its own in-house recycling process with the Volkswagen Group Components subsidiary based in Salzgitter [35]. Using a pyrometallurgy process

associated with hydrometallurgical post-treatment, the group is recovering over 95% of the battery weight from the process and is targeting a closed-loop process of the major cathodes materials. Regarding battery second life, VW batteries are expected to be used as components for flexible charging stations or for grid energy storage with TMH and Belectric partnership.

Renault is setting up the Flins plant in France as its new hub for a circular economy (Re-factory) and it will be deployed gradually between 2021 and 2024 [19]. The plant will be achieving the dismantling and sorting of battery components while the recycling should be taken over by its consortium with Veolia and Solvay. The French company is targeting 80% share of recycled strategic materials to reintegrate into new battery production as closed loop in 2030. The carmaker is also leading an Advanced Battery Storage project in order to use car batteries as stationary storage. Renault also partnered with Powervault in order to use car batteries in home battery systems.

Volvo is developing its own in-house battery recycling process including hydrometallurgy in order to achieve closed loop recycling [37]. Volvo is working on battery second life projects: used batteries will be used as solar-powered energy storage systems to power charging stations (partnership with BatteryLoop) and also as fast-balancing stationary storage (partnership with Fortum & Comsys AB). The Swedish carmaker also has a pick-up service to recover all used batteries.

Daimler is dismantling and sorting its batteries with its Accumotive subsidiary and the recycling should be done by Remondis to reintroduce raw materials into the production cycle. In 2016, the OEM declared achieving 70 to 80% battery recycling rates. Moreover, Daimler adopted a Human Rights Respect System while monitoring its supply chain according to OECD standards.

BMW has a partnership with Duesenfeld in order to achieve a 96% EV battery recycling rate. Second life uses are also planned by the German OEM as batteries could be used in energy storage applications or in mobile power units made by Off Grid Energy.

JLR's venture capital subsidiary has invested in a battery recycling company called Battery Resources that is developing an innovative closed-loop recycling process. The British OEM is also planning to use batteries in domestic applications in a project with Connected Energy and the University of Warwick.

Ford is part of a blockchain battery recycling project with the US energy department and Everledger, and recently planned in-house R&D on recycling in its new Ion Park battery center of excellence.

Stellantis joint venture ACC intends to recycle more than 90% of its cells. Current Stellantis and ACC recycling partners are unclear but it is known that PSA had a partnership with the French company SNAM in the past.

Hyundai partnered with the Finnish company Wärtsilä to reuse batteries in energy storage applications, and with Lithion Recycling for the material recycling.

Toyota has a partnership with Umicore's battery recycling facility in Hoboken (Belgium).

Battery Innovation (2 points)

This criterion takes into account partnerships and carmakers in-house R&D to assess their implication in innovative battery technologies.

Table 9: Battery innovation rating

OEM	Battery Innovation (/2)
VW	2
BMW	2
Daimler	2
Ford	2
JLR	2
Toyota	1
Volvo Cars	1
Stellantis	1
Renault	1
Hyundai-Kia	1

VW set-up a centre of excellence for battery cells in Salzgitter [75] while its Porsche brand is involved in high-performance batteries development. The German carmaker also counts on its partnership with QuantumScape to use solid state batteries from 2025.

Daimler's in-house battery R&D [76] is associated with key strategic partners such as CATL and Farasis. Its partnership with Sila Nanotechnologies aims to replace graphite electrodes with silicon-dominant composite materials and achieve higher energy density and cycle life. It also partnered with Hydro-Québec for solid-state battery development.

BMW has a Battery Cell Competence Centre in Munich [77] and a partnership with Solid Power to produce solid-state batteries from 2027.

Ford Ion Park battery [47] center aims to develop and manufacture lithium ion and solid-state battery cells while the carmaker also has partnerships with Solid Power.

JLR invested in the National Battery Prototyping Centre [78] in the UK and is among the supporters of the British solid-state battery pioneer Ilika.

Toyota has a joint venture with Panasonic for its solid-state battery development and aims to use the technology in its cars from 2025.

Volvo relies on an in-house battery lab to improve the range and reliability of its battery systems.

Stellantis is expected to develop solid-state batteries with Saft as part of the ACC joint venture.

Both **Renault** and **Hyundai-Kia** are involved in the development of solid-state batteries with Ionic Materials.

Charging and energy strategy (10 points)

Ten points are assigned to the charging and energy strategy of each OEM depending on their support to private and public charging infrastructure roll out and energy solution development such as Vehicle-to-Grid (V2G) or stationary storage.

In this ranking, direct and early involvements and investments are rewarded. A good strategy would include investments in public charging (in residential areas, commercial areas, fast-charging networks or dedicated charging hubs), dedicated subsidiaries to support the roll-out of the infrastructure for home-charging or charging solutions for companies and fleets. The ranking also rewards OEMs with strategies regarding the balance of the electric grid or to support stationary storage and smart energy management solutions.

As an example of good practice, Tesla was the first to massively invest in the deployment of a public charging infrastructure with its Supercharger fast-charging network that exceeded 25,000 stations in 2021. The carmaker also developed the “Destination charging network”: High Power Wall Chargers can be installed freely by Tesla in businesses and commercial parking. Tesla also has its own home-charging solution that can be used with its Powerwall system, a home storage system for solar panels.

Table 10: Charging and energy strategy rating

OEM	Charging & Energy Strategy (/10)
VW	7
Renault	6
Stellantis	6
BMW	6
Daimler	6
Hyundai-Kia	3
Ford	3
Volvo Cars	3
JLR	3
Toyota	1

VW has an ambitious charging and energy strategy with its dedicated subsidiary Elli [16]. The subsidiary provides wallboxes for private charging, charging stations for businesses and mobility services across a wide public charging network. The carmaker committed to support the deployment of 18,000 fast-charging points [13] across Europe in partnership with IONITY, Enel, Iberdrola, BP, and ARAL. It also plans to make the electric car part of the energy system by implementing bidirectional charging as soon as 2022.

Renault owns two subsidiaries in the charging field: Elexent [40] is dedicated to commercial fleet charging solutions and Mobilize to smart charging solutions. The French carmaker was part of several public charging projects such as INCIT-EV, E-VIA FLEX-E, Corri-Door or FAST-E. And some Renault ZOE prototypes are used in V2G test projects.

Stellantis is part of the Free2Move eSolutions [42] joint venture with Engie for a wide range of solutions from charging infrastructures, home charging subscriptions and advanced energy services such as Vehicle-to-Grid (V2G).

BMW is part of the YOUR NOW joint ventures with Daimler that includes Digital Charging Solutions GmbH (DCS [38]) to develop public charging solutions for OEMs and fleet operators. BMW is also part of the IONITY high-power charging network. The carmaker provides a complete package for home-charging including a wallbox and installation services to electricity from renewable energy sources. It is also testing bidirectional charging technologies.

Daimler is also part of the DCS joint venture and the IONITY network. It invested in The Mobility House, a charging solutions provider that operates stationary energy storage systems built with EV batteries. Together, they are also planning the integration of electric vehicles into the power grid.

Hyundai-Kia plans bi-directional power conversion function in its new E-GMP platform while it also joined the IONITY network in Europe.

Ford has different partnerships to supply its Ford Connected Wallbox across Europe and is also part of the IONITY charging network.

Volvo launched the Volvo Recharge Highways project in Italy to roll out public fast-charging stations. The carmaker is also part of the V2X Swedish Project to accelerate the development of V2G and Vehicle-to-Home technologies.

JLR partnered NewMotion in the deployment of fast chargers in the UK and is working on a V2G project with the University of Warwick.

Toyota invested in Nuvve that already delivered multiple V2G projects, including a first commercial V2G operation in Denmark.

6.6. PHEV range proxy

T&E's range proxy metric is an estimate of PHEVs ability to drive on the battery. The metric is calculated based on technical data provided in IHS Markit forecast database: the battery capacity of the vehicle, the system power, and the car segment. Technical data of cars that will be produced in 2030 comprise a high level of uncertainty but they can be used to estimate overall trends. This range proxy metric is not meant to be used to calculate the exact range value of a specific car version but rather to estimate overall trends when averaging data by segment or carmakers.

The index is based on the following observations:

- The range driven in electric mode is proportional to the battery capacity.
- The range is inversely proportional to the overall mass of the car.
- 2019 EEA registration data [56] shows a correlation between vehicle mass and the power of their internal combustion engine specific to each car segment.

The range index is also taking into account the overall hybrid peak power of the car (ICE and e-motor combined). This peak power accounts for the difference of mass between PHEVs of different e-motor power. Additionally, as drivers tend to exploit the power of their car in real life with more dynamic driving than WLTP lab tests, a shorter range is expected for PHEVs that have higher e-motor power.

Therefore, the range proxy metric, r , for a given PHEV, is estimated with the following formula:

$$r = f \times \frac{C}{a_{seg} \times P + b_{seg}}$$

With the following parameters:

- C is the battery capacity, in kWh
- P is the system power, in kW
- The suffix seg indicates an average value taken from the vehicle segment. PHEVs are included in B, C, D and E segments.
- Both a_{seg} (in kg/kW) and b_{seg} (in kg) are parameters defined by linear regression from 2019 EEA data grouped by segment. The denominator ($a_{seg} \cdot P + b_{seg}$) represents the correlation between vehicle mass and power of PHEVs.
- The factor f [km.kg/kWh] is used to scale the range proxy so that the metric is representative of realistic range. To define this factor, EPA electric range data³⁸ for PHEV models sold between 2018 and 2021 were compiled and the proxy was scaled in order to minimize the root mean square error between the average range proxy and the EPA range. With this scaling, on average, a model with a 14 kWh battery and a 183 kW system power is expected to have a range proxy of 48km. (1/f) is a reference with the physical meaning of an electric consumption by unit of mass.

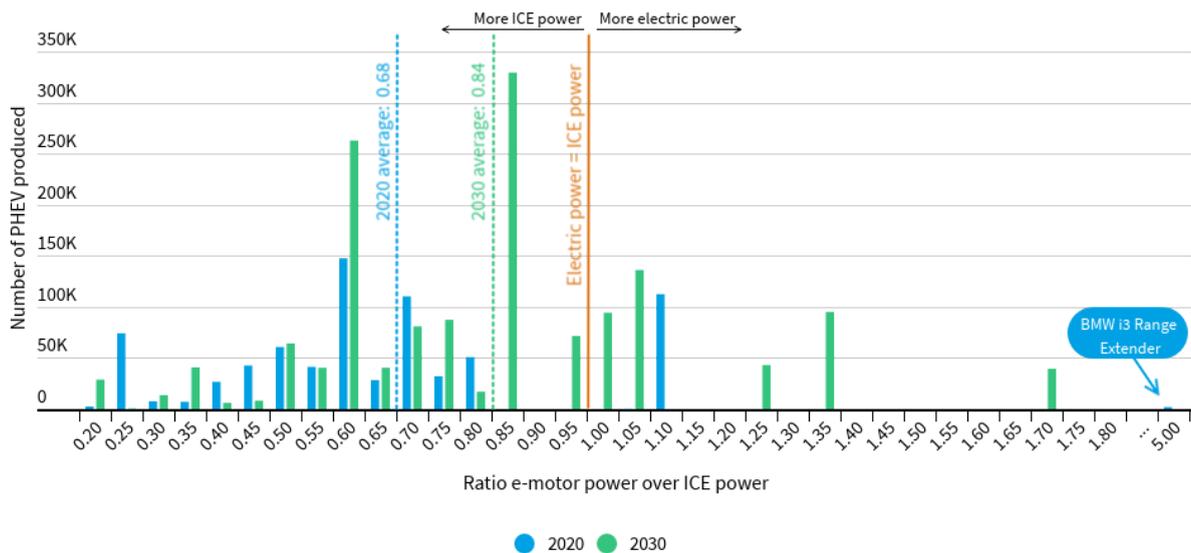
³⁸ US EPA test cycles results were used as they provide electric range closer to real world driving range than WLTP cycle. Data extracted from the official U.S. government source for fuel economy information [79].

The scaling of the range proxy metric is based on current PHEV performances but, in the future, the following trends are expected:

- The electric drive system efficiency of PHEVs is expected to be improved, for instance with better battery energy density.
- But, on the other hand, the overall vehicle mass is expected to keep increasing and it is likely to offset efficiency improvements. Indeed, EEA registration trends show an increase of vehicle mass due to the popularity of SUVs and increase in equipment levels.
- Moreover, PHEV system power is expected to grow by 15% from 2020 to 2030 (from 185 to 212 kW) thanks to an increase in electric motor power. Even if this power increase is positive to avoid running the ICE in broader driving conditions, the consequence would be a decrease in the range in electric mode with the same battery capacity as drivers are expected to operate at higher power in zero-emission mode.
- The battery capacity is also expected to increase by around 50% from 2020 to 2030.

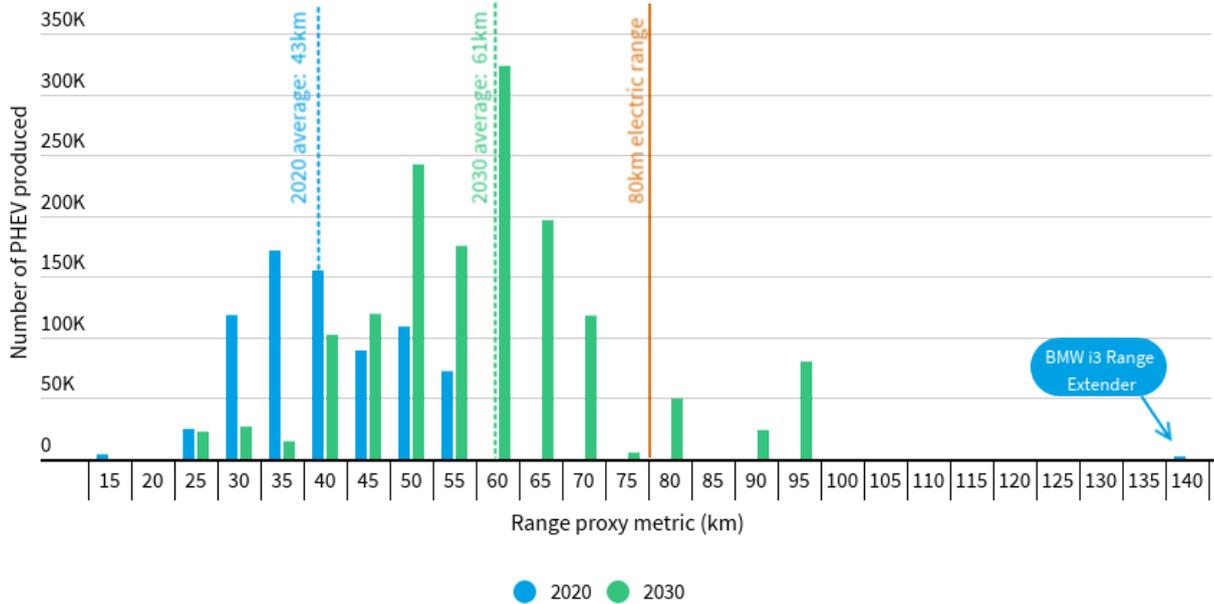
All in all, PHEVs average range driven in electric mode is expected to increase by around 43% from 43km in 2020 to 61km in 2030.

6.7. PHEV performance distribution



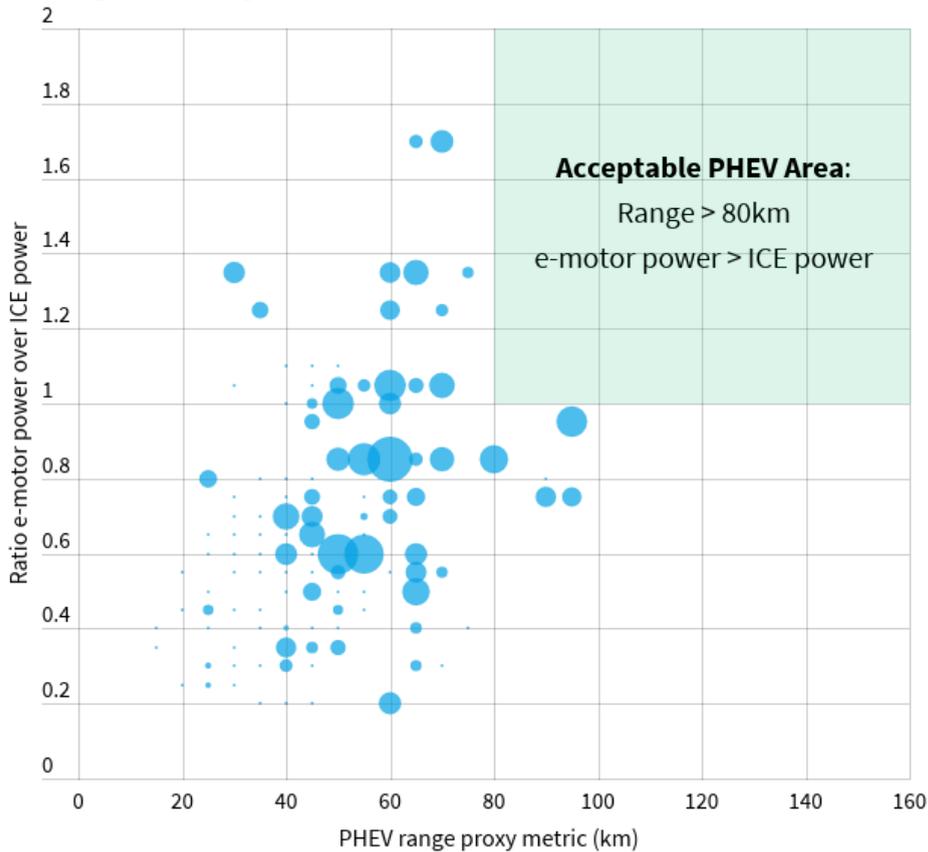
Source: T&E internal modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 35: Power ratio distribution across PHEVs produced in the EU



Source: T&E internal modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

Figure 36: Range proxy distribution across PHEVs produced in the EU



Source: T&E internal modelling based on IHS Markit, Automotive, European Light Vehicle Production based Powertrain Forecast, April 2021

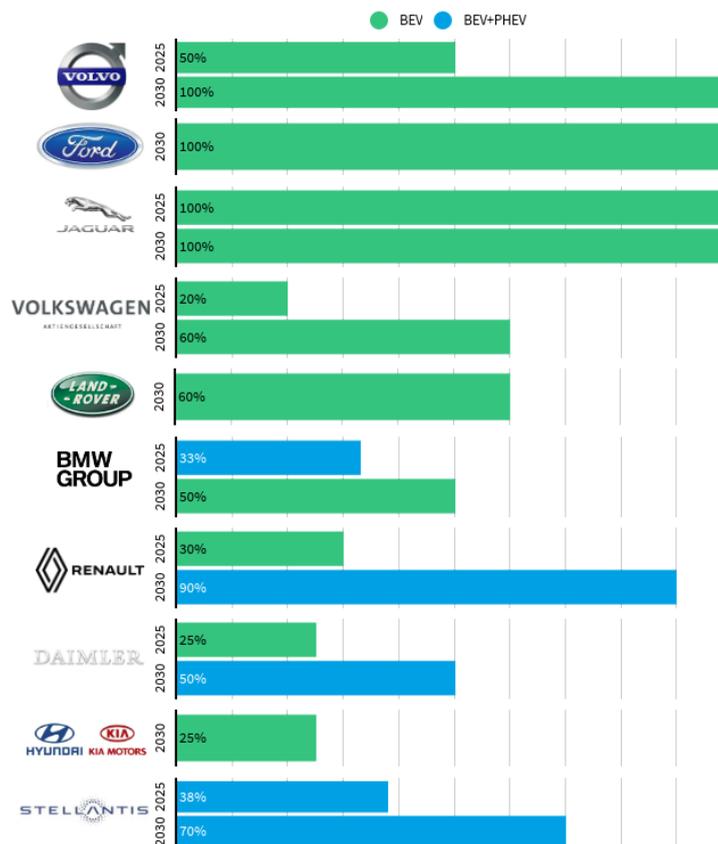
Figure 37: Power ratio and range proxy of PHEVs produced in 2030 in Europe. Circle area proportional to production volumes.

6.8. OEMs public BEV sales announcements

Table 11: carmakers public BEV sales targets

	OEM	Sales in 2025	Sales in 2030
	BMW	33% BEV+PHEV	50% BEV / Mini brand: 100% BEV
	Daimler	Up to 25% BEV	50% BEV+PHEV
	Ford		100% BEV
	Hyundai-Kia	Kia brand: 20% BEV	Global group: 25% BEV
	JLR	Jaguar brand: 100% BEV	Land Rover brand: 60% ZEV
	Renault	Renault brand: 30% BEV	Renault brand: 90% BEV+PHEV
	Stellantis	38% BEV+PHEV	70% BEV+PHEV / Fiat brand: 100% BEV
	Toyota	10% BEV+FCEV	
	Volvo Cars	50% BEV + 50% PHEV	100% BEV
	Volkswagen	20% BEV	Group: 60% BEV / VW brand: 70% BEV

Source: Press and OEM public information

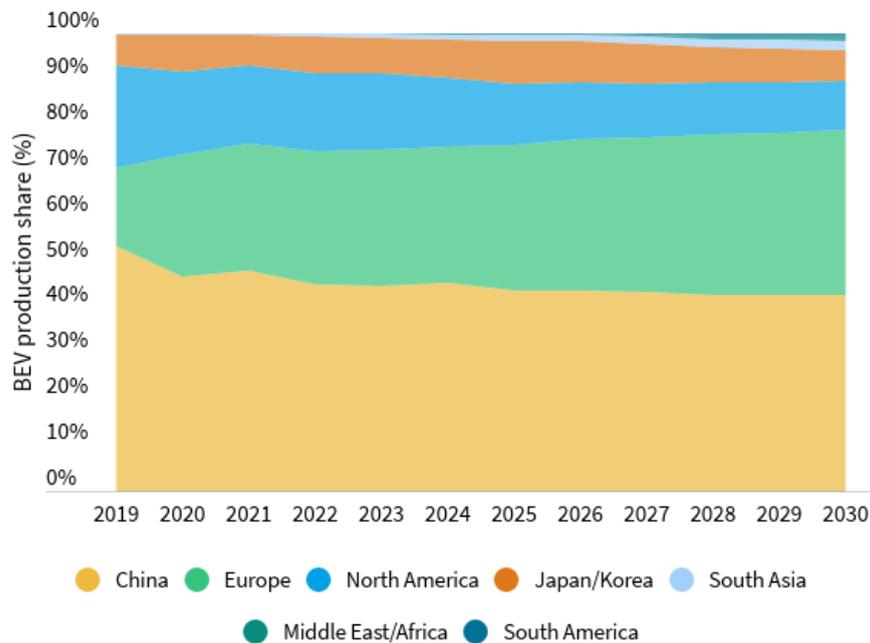


NB: Renault target applies only to brand, not to Renault group as a whole.

Figure 38: Public BEV sales targets by OEMs

6.9. The position of Europe in the world car market

In the global market, the production of BEV is expected to grow from 1.8 million in 2019 to around 21 million in 2030 with Europe and China the main producers of electric vehicles.



Source: IHS Markit, Automotive, Global Light Vehicle Production based Powertrain Forecast, April 2021

Figure 39: BEV production split between regions

In 2020, 27% of the world's BEVs were produced in Europe and this share is expected to grow to 36% in 2030.

6.10. Analysis of the EU car CO₂ standards

The following assumptions were used to calculate the relationship between the car CO₂ reduction targets and the level of EV sales in Europe for 2025 and 2030.

- ICE improvement (including mild and full hybrids): 2.3% annual improvement from 2021 to 2025 and 2.0% from 2025 to 2030 based on the following:
 - Mild hybrid, full hybrid and regular ICE estimate share of sales based on IHS Markit EU production forecast: 7% full hybrids in 2025 and 11% in 2030; 35% mild hybrids in 2025 and 21% in 2030. As a result, the share of conventional hybrids is 23% in 2025 and only 1% in 2030.
 - Full hybrids provide a CO₂ reduction of 20% compared to conventional ICEs and 9% for mild hybrids.

- 1.5% annual improvement for all hybrids and ICE from 2021 and 2025, and 1.0% for hybrids between 2025 and 2030 (0% for conventional ICEs).
- PHEV emissions assumed (WLTP): 49 g/km in 2021; 42 g/km in 2025 and 30 g/km. This is derived from the assessment of the increase in the ‘range proxy’ presented in this report (from 45 km in 2021 to 52 km in 2025 and 61 km in 2030) and the associated increase of the WLTP utility factor (from approximately 0.73 in 2020, to 0.75 in 2025 and 0.81 in 2030).
- Regulatory flexibilities (for more see T&E’s 2020 car CO₂ report [80]):
 - Eco-innovation: 3 g/km of credits for each ICE sold
 - Mass adjustment of the target: 2 g/km weakening of the target
 - WLTP test optimisation: 5% improvement of ICE emissions thanks to test optimisation.

Endnotes

1. Transport & Environment. (2021). *CO2 targets propel European EV sales*. Retrieved from <https://www.transportenvironment.org/publications/co2-targets-propel-european-ev-sales>
2. Renault Group Climate Report. (2021, April). *Groupe Renault*. Retrieved from <https://www.renaultgroup.com/wp-content/uploads/2021/04/climate-report-renault-group.pdf>
3. Bloomberg, N. E. F. (2021). *Hitting the EV inflection Point*. Retrieved from <https://www.transportenvironment.org/publications/hitting-ev-inflection-point>
4. Transport & Environment. (2020). *A new Dieselgate in the making*. Retrieved from <https://www.transportenvironment.org/publications/plug-hybrids-europe-heading-new-dieselgate>
5. Plötz, P., Moll, C., Biecker, G., Mock, P., & Li, Y. (2020). *Real-world usage of plug-in hybrid electric vehicles: Fuel consumption, electric driving, and CO₂ emissions*. International Council on Clean Transportation. Retrieved from <https://theicct.org/publications/phev-real-world-usage-sept2020>
6. Mock, P., & Díaz, S. (2021). *Pathways to decarbonization: the European passenger car market in the years 2021-2035*. International Council on Clean Transportation. Retrieved from <https://theicct.org/publications/decarbonize-EU-PVs-may2021>
7. Daimler ends hydrogen car development because it’s too costly. (2020, April 22). *Electrek*. Retrieved June 12, 2021, from <https://electrek.co/2020/04/22/daimler-ends-hydrogen-car-development-because-its-too-costly/>
8. VW joins ranks of car makers rejecting hydrogen fuel cells. (2021, March 16). *The Driven*. Retrieved June 12, 2021, from <https://thedriven.io/2021/03/16/vw-joins-ranks-of-car-makers-rejecting-hydrogen-fuel-cells/>
9. BMW fully electrifies Mini. (2021, March 12). *Spiegel*. Retrieved from <https://www.spiegel.de/auto/bmw-setzt-beim-mini-komplett-auf-e-antrieb-a-41cdf660-0002-0001-0000-000176230907>
10. Volvo Cars to be fully electric by 2030. (2021, March). *Volvo Cars*. Retrieved from <https://www.media.volvocars.com/global/en-gb/media/pressreleases/277409/volvo-cars-to-be-fully-electric-by-2030>
11. Volvo will slide a skateboard under its electric XC90 SUV. (2021, March). *Green Car Reports*. Retrieved from https://www.greencarreports.com/news/1131454_volvo-will-slide-a-skateboard-under-its-electric-xc90-suv
12. How we become CO₂-neutral. (2021, May 18). *Volkswagen*. Retrieved from <https://www.volkswagenag.com/en/news/stories/2021/05/29-climate-measures-of-the-volkswagen-group.html>

13. Power Day: Volkswagen presents technology roadmap for batteries and charging up to 2030. (2021, March). *Volkswagen*. Retrieved from <https://www.volkswagenag.com/en/news/2021/03/power-day--volkswagen-presents-technology-roadmap-for-batteries-.html>
14. The Modular Electrification Toolkit (MEB) is providing Volkswagen with its foundation for mobility of the future. (n.d.). *Volkswagen*. Retrieved from <https://www.volkswagenag.com/en/news/stories/2017/02/the-e-mobility-module.html>
15. First details PPE electric car platform for future Audis and Porsches. (2020, April). *Motor Authority*. Retrieved from https://www.motorauthority.com/news/1113147_first-details-ppe-electric-car-platform-future-audis-porsches
16. Elli. (n.d.). *Elli*. Retrieved from <https://www.elli.eco/en/about-us>
17. AESC to build a battery plant in Sunderland. (2021, May 27). *Electrify*. Retrieved from <https://www.electrify.com/2021/05/27/aesc-to-build-battery-plant-in-sunderland/>
18. À Douai, 2000 emplois créés pour les batteries de Renault. (2021, May 28). *Le Figaro*. Retrieved from <https://www.lefigaro.fr/entrepreneur/a-douai-2000-emplois-creees-pour-les-batteries-de-renault-20210528>
19. Groupe Renault created the first European factory dedicated to the circular economy of mobility in Flins. (2020, November). *Green Car Congress*. Retrieved from <https://www.greencarcongress.com/2020/11/20201126-renault.html>
20. Hyundai Motor Group to Lead Charge into Electric Era with Dedicated EV Platform “E-GMP.” (2020, December 1). *Hyundai*. Retrieved from <https://www.hyundai.com/en-us/releases/3211>
21. Ford Europe goes all-in on EVs on the road to sustainable profitability. (2021, February). *Ford*. Retrieved from <https://media.ford.com/content/fordmedia/feu/en/news/2021/02/17/ford-europe-goes-all-in-on-evs-on-road-to-sustainable-profitability.html>
22. Ford, Volkswagen sign agreements for joint projects on commercial vehicles, EVs, autonomous driving. (2020, June 10). *Ford*. Retrieved from <https://media.ford.com/content/fordmedia/fna/us/en/news/2020/06/10/ford-volkswagen-sign-agreements-for-joint-projects.html>
23. Automotive Cells Company. (n.d.). *ACC*. Retrieved from <https://www.acc-emotion.com/>
24. Ambition 2039: Our path to CO₂-neutrality. (n.d.). *Daimler*. Retrieved May 2021, from <https://www.daimler.com/sustainability/climate/ambition-2039-our-path-to-co2-neutrality.html>
25. BMW and Mercedes-Benz take opposing views on flexible EV manufacturing. (2020, February 5). *Electrek*. Retrieved from <https://electrek.co/2020/02/05/bmw-and-mercedes-benz-take-opposing-views-on-flexible-ev-manufacturing/>
26. Electric First: Mercedes-Benz’s global battery-production network grows. (2020, May 26). *Daimler*. Retrieved from <https://media.daimler.com/marsMediaSite/en/instance/ko.xhtml?oid=46438528>
27. A New Era, a New Class: BMW Group steps up technology offensive with comprehensive realignment – uncompromisingly electric, digital and circular. (2021, March 17). *BMW Group*. Retrieved from <https://www.press.bmwgroup.com/global/article/detail/T0327929EN/a-new-era-a-new-class--bmw-group-step-up-technology-offensive-with-comprehensive-realignment-%E2%80%93-uncompromisingly-electric-digital-and-circular?language=en>
28. BMW’s electric-focused architecture is for all. (2021, March 29). *Automotive News*. Retrieved from <https://www.autonews.com/design/bmws-electric-focused-architecture-all>
29. Jaguar Land Rover reimagines the future of modern luxury by design. (2021, February). *Jaguar Land Rover*. Retrieved from <https://media.jaguarlandrover.com/news/2021/02/jaguar-land-rover-reimagines-future-modern-luxury-design>
30. EV Database. (n.d.). *EV Database*. Retrieved May 2021, from <https://ev-database.org/>
31. Transport & Environment. (2019). *Electric surge: Carmakers’ electric car plans across Europe 2019-2025*. Retrieved from

<https://www.transportenvironment.org/publications/electric-surge-carmakers-electric-car-plans-across-europe-2019-2025>

32. Volkswagen Increases Stake In Northvolt And Acquires Joint Venture. (2021, March 15). *InsideEVs*. Retrieved from <https://insideevs.com/news/494412/volkswagen-increases-stake-northvolt-acquires-joint-venture/>
33. Porsche announces the construction of a battery cell factory in Tübingen. (2021, April 24). *FAZ*. Retrieved from <https://www.faz.net/aktuell/wirtschaft/auto-verkehr/porsche-baut-jetzt-eine-batteriezellenfabrik-in-tuebingen-17310007.html>
34. Battery maker Northvolt gets \$14 billion order as Volkswagen raises ownership. (2021, March 15). *Reuters*. Retrieved from <https://www.reuters.com/article/us-northvolt-volkswagen-idUSKBN2B71GK>
35. Pilot plant battery recycling. (2021, January 29). *Volkswagen*. Retrieved from <https://www.volkswagenag.com/en/news/stories/2021/01/interview-with-thomas-schmall-and-mark-moeller.html>
36. Geely looks to build a battery factory for 42 GWh in China. (2021, March 15). *Electrive*. Retrieved from <https://www.electrive.com/2021/03/15/geely-looks-to-build-battery-factory-for-42-gwh-in-china/>
37. Volvo to leverage recycling to cut costs. (2021, April 21). *Electrive*. Retrieved from <https://www.electrive.com/2021/04/21/volvo-to-leverage-recycling-to-cut-costs/>
38. Digital charging solutions. (n.d.). *DCS*. Retrieved from <https://digitalchargingsolutions.com/web/dcs-global/about>
39. 7 benefits of the Mercedes MMA platform in Daimler's words. (2021, May 25). *TopElectricSUV*. Retrieved from <https://topelectricsuv.com/news/mercedes-benz/2025-mercedes-eqc-details/>
40. Elexent: charging solutions for companies. (2020, June 30). *Groupe Renault*. Retrieved from <https://easyelectriclife.groupe.renault.com/en/expert-view/elexent-charging-solutions-for-companies/>
41. The CMF-EV platform advances the new generation of electric vehicles. (2020, February 3). *Groupe Renault*. Retrieved from <https://easyelectriclife.groupe.renault.com/en/outlook/technology/the-cmf-ev-platform-advances-the-new-generation-of-electric-vehicles/>
42. "Free2Move eSolutions": the name of the JV between Stellantis and Engie EPS to create a new world-leading provider of e-mobility products & services. (2021, March 31). *Engie*. Retrieved from <https://engie-eps.com/corporate/free2move-esolutions-the-name-of-the-jv-between-stellantis-and-engie-eps/>
43. Stellantis maps out future EV platforms with up to 497 miles of range. (2021, April 20). *AutoExpress*. Retrieved from <https://www.autoexpress.co.uk/peugeot/354798/stellantis-maps-out-future-ev-platforms-497-miles-range>
44. BMW Group continues to drive electromobility: Long-term supply contract with Northvolt for battery cells from Europe concluded. (July 16, 2020). *BMW Group*. Retrieved from <https://www.press.bmwgroup.com/global/article/detail/T0311274EN/bmw-group-continues-to-drive-electromobility-long-term-supply-contract-with-northvolt-for-battery-cells-from-europe-concluded?language=en>
45. Toyota Debuts All-Electric SUV Concept. (2021, April 18). *Toyota*. Retrieved from <https://pressroom.toyota.com/toyota-debuts-all-electric-suv-concept/>
46. Ford commits to manufacturing batteries, to form a new joint venture with SK innovation to scale NA battery deliveries. (2021, May 20). *Ford*. Retrieved from <https://media.ford.com/content/fordmedia/fna/us/en/news/2021/05/20/ford-commits-to-manufacturing-batteries.html>
47. Ford takes its first step toward producing its own electric car batteries. (2021, April 27). *The Verge*. Retrieved from <https://www.theverge.com/2021/4/27/22405470/ford-ev-battery-manufacturing-research-center>
48. Ford confirms two new flexible electric car architectures. (2021, May 27). *AutoExpress*. Retrieved from <https://www.autoexpress.co.uk/ford/355124/ford-confirms-two-new-flexible-electric-car-architectures>
49. Dedicated EV Platform Planned For Land Rover Discovery Sport, Range Rover Evoque. (2021, March 2). *InsideEVs*. Retrieved from <https://insideevs.com/news/491792/ev-platform-next-discovery-sport-evoque/>

50. Hybrid carmakers accused of “con” over zero-emissions claims. (2020, March 1). *The Guardian*. Retrieved June 12, 2021, from <https://www.theguardian.com/business/2020/mar/01/hybrid-carmakers-accused-of-con-over-zero-emissions-claims>
51. BMW i3 94 Ah. (n.d.). *EV Database*. Retrieved May 2021, from <https://ev-database.org/car/1068/BMW-i3-94-Ah>
52. 2017 BMW i3 REX (94 Amp-hour battery). (n.d.). *FuelEconomy.gov*. Retrieved May 2021, from <https://www.fueleconomy.gov/feg/Find.do?action=sbs&id=38229>
53. Technical Specifications for the BMW i3 (94Ah), valid from 07/2016. (n.d.). *BMW Group*. Retrieved May 2021, from <https://www.press.bmwgroup.com/global/article/detail/T0259598EN/technical-specifications-for-the-bmw-i3-94ah-valid-from-07/2016?language=en>
54. Transport & Environment. (2019). *New car CO2 standards: Is the job of securing electric cars in Europe done?* Retrieved from <https://www.transportenvironment.org/publications/new-car-CO2-standards-job-securing-electric-cars-europe-done>
55. Transport & Environment. (2021). *PHEVs and the car CO2 review: Europe’s chance to tackle fake electrics*. Retrieved from <https://www.transportenvironment.org/publications/phevs-and-car-co2-review-europe%E2%80%99s-chance-tackle-fake-electrics>
56. Monitoring of CO2 emissions from passenger cars – Regulation (EU) 2019/631. (n.d.). *EEA*. Retrieved from <https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-19>
57. Stellantis reveals key details of electrification plans. (2021, April 18). *Electrive*. Retrieved from <https://www.electrive.com/2021/04/18/stellantis-reveals-key-details-of-electrification-plans/>
58. Fiat to go fully electric by 2030. (2021, June 5). *Electrive*. Retrieved from <https://www.electrive.com/2021/06/05/fiat-to-go-fully-electric-by-2030/>
59. Transport & Environment. (2018). *Roadmap to decarbonising European cars*. Retrieved from <https://www.transportenvironment.org/publications/roadmap-decarbonising-european-cars>
60. Transport & Environment. (2017). *Carmakers failing to hit their own goals for sales of electric cars*. Retrieved from <https://www.transportenvironment.org/publications/carmakers-failing-hit-their-own-goals-sales-electric-cars>
61. ACEA. (2021). *ACEA Position Paper: Review of the CO2 Regulation for cars and vans*. Retrieved from https://www.acea.auto/uploads/publications/ACEA_Position_Paper-Review_of_the_CO2_Regulation_for_cars_and_vans.pdf
62. ICCT. (2020). *Fact sheet: Real-world usage of plug-in hybrid electric vehicles*. Retrieved from <https://theicct.org/publications/phev-fs-eng-sept2020>
63. Guest post: Why the low carbon transition may be much cheaper than models predict. (2021, May 12). *CarbonBrief*. Retrieved from <https://www.carbonbrief.org/guest-post-why-the-low-carbon-transition-may-be-much-cheaper-than-models-predict>
64. How Volkswagen becomes a tech company. (2021, February 18). *Manager Magazin*. Retrieved from <https://www.manager-magazin.de/unternehmen/autoindustrie/volkswagen-mit-apollon-artemis-und-trinity-soll-vw-zur-techcompany-werden-a-00000000-0002-0001-0000-000175390522>
65. VW Group to unify EV platforms with SSP due in 2026. (2021, March 16). *Motor Authority*. Retrieved from https://www.motorauthority.com/news/1131592_vw-group-to-unify-ev-platforms-with-ssp-due-in-2026
66. Electric Volvo XC20 SUV planned to sit below XC40. (2021, March 2). *AutoExpress*. Retrieved from <https://www.autoexpress.co.uk/volvo/106855/electric-volvo-xc20-suv-planned-sit-below-xc40>
67. Renault 5 concept headed for series production. (2021, January 25). *Electrive*. Retrieved from <https://www.electrive.com/2021/01/25/renault-5-prototype-headed-for-series-production/>
68. Comment Stellantis compte se convertir à 100 % dans l’électrique. (2021, April 16). *Automobile Propre*.

- Retrieved from
<https://www.automobile-propre.com/comment-stellantis-compte-se-convertir-a-100-dans-lelectrique/>
69. eVMP : une plateforme grande autonomie pour le Peugeot 3008 électrique. (2020, July 28). *Automobile Propre*. Retrieved from
<https://www.automobile-propre.com/evmp-une-plateforme-grande-autonomie-pour-le-peugeot-3008-electrique/>
 70. New Fiat 500e. (2020, March 4). *Autocar*. Retrieved from
<https://www.autocar.co.uk/car-news/motor-shows-geneva-motor-show/new-fiat-500e-technical-details-electric-city-car-leaked>
 71. Toyota, Panasonic announce battery venture to expand EV push. (2019, January 22). *Automotive News*. Retrieved from
<https://europe.autonews.com/automakers/toyota-panasonic-announce-battery-venture-expand-ev-push>
 72. Volkswagen Group, BASF, Daimler AG and Fairphone start partnership for sustainable Lithium mining in Chile. (2021, June 8). *Automotiveworld*. Retrieved from
<https://www.automotiveworld.com/news-releases/volkswagen-group-basf-daimler-ag-and-fairphone-start-partnership-for-sustainable-lithium-mining-in-chile/>
 73. BMW Group steps up sustainable sourcing of lithium for battery cell production to ensure rapid e-mobility expansion. (2021, March 30). *Automotive World*. Retrieved from
<https://www.automotiveworld.com/news-releases/bmw-group-steps-up-sustainable-sourcing-of-lithium-for-battery-cell-production-to-ensure-rapid-e-mobility-expansion/>
 74. Raw material supplies for battery cells: BMW Group sources sustainable cobalt worth around 100 million euros from Morocco. (2020, July 9). *Automotive World*. Retrieved from
<https://www.automotiveworld.com/news-releases/raw-material-supplies-for-battery-cells-bmw-group-sources-sustainable-cobalt-worth-around-100-million-euros-from-morocco/>
 75. “Our Batteries Last the Life of a Car.” (n.d.). *Volkswagen*. Retrieved from
<https://www.volkswagenag.com/en/news/stories/2019/04/our-batteries-last-the-life-of-a-car.html>
 76. Mercedes-EQ starts production of battery systems for the new EQS. (2021, March 23). *Daimler*. Retrieved from
<https://www.daimler.com/innovation/digitalisation/industry-4-0/battery-production-hedelfingen.html>
 77. BMW opens a Battery Competence Centre in Munich. (2019, November 14). *Electrive*. Retrieved from
<https://www.electrive.com/2019/11/14/bmw-opens-battery-competence-centre-in-munich/>
 78. JLR and the UK government announce national EV battery hub plans. (2017, June 1). *Autovista Group*. Retrieved from
<https://www.autovistagroup.com/news-and-insights/jlr-and-uk-government-announce-national-ev-battery-hub-plans>
 79. Plug-In Hybrids fuel economy database. (n.d.). *FuelEconomy.gov*. Retrieved May 2021, from
<https://www.fueleconomy.gov/feg/PowerSearch.do?action=noform&path=1&year1=2011&year2=2021&vtype=Plug-in+Hybrid&pageno=1&rowLimit=50>
 80. Transport & Environment. (2020). *Mission (almost) accomplished! Carmakers' race to meet the 2020/21 CO2 targets, and the EU electric cars market*. Retrieved from
<https://www.transportenvironment.org/publications/mission-almost-accomplished-carmakers-race-meet-2020-21-co2-targets-and-eu-electric-cars>