DRIVING INTO A LOW EMISSIONS FUTURE

Looking beyond 2021

Bringing Ingenuity to Life
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FOREWORD

For many years, car making was a stable business that experienced incremental changes in technology and markets but where the fundamentals remained the same. All that has changed. Manufacturers need to manage significant technological, commercial, market and political developments like autonomous driving, new mobility platforms, connectivity, customer demand for low emission vehicles and Brexit.

Legislation and regulation are also playing an important part, with minds increasingly focused on the European Union (EU) 2021 CO₂ emissions targets. That means car makers face some difficult choices about their future direction.

As our latest analysis shows, some car makers have got their strategy right and will meet their targets easily, but others have woken up too late and will struggle. While many of these late risers have plans for new low emission models, it will be hard for them to implement their plans fast enough in the next three years to make a real difference in meeting their targets. Those companies at risk of missing their targets will need to prioritise the selling, marketing and pricing of these vehicles to counter negative perceptions in the market.

Yet it would be a mistake to let the focus on 2021 obscure the challenges further ahead. The EU is debating its next set of emissions targets for 2025 and 2030 and these will be even more demanding. The European automotive industry invests close to 55 billion Euros in research and development annually, a large percentage of which goes towards fuel-efficiency technologies.
Car makers will have to be very clear about the kind of strategy and technology they will need to invest in to meet those future targets, recognising that even today’s winners could struggle.

Moving from internal combustion engines to new powertrain technologies will not be easy and will require different technical and commercial approaches. It will be expensive and complex, but the automotive industry has a good track record of innovation. New technology, not least in batteries, is developing fast. With the right strategy, manufacturers can come out winners.

We have deep expertise helping automotive companies combine strategy, technology and innovation to go further, faster. We draw on our rich history of ingenious thinking as we work side-by-side with industry partners. For us, the challenge goes beyond meeting compliance standards.

It’s about building a positive human future by reducing emissions. We’re energised by the immensity of the challenge at hand. And we have every reason to believe that the automotive sector will succeed in providing consumers with the new and attractive products that meet future emissions requirements.

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INTRODUCTION

EU CO₂ emissions regulations are the most stringent in the world. Each car maker has a specific target for their registered car fleet in 2021. The aim is to have a European average of 95 grams of CO₂ per kilometre.

Car makers face penalties of €95 for every gram of CO₂ they are above their limit, multiplied by the number of cars they registered in the EU in the previous year. In contrast, China has targets of 117g/km, Japan 122g/km and the US 125g/km, all to be reached by 2020.
<table>
<thead>
<tr>
<th></th>
<th>Europe</th>
<th>USA</th>
<th>China</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current emission test</td>
<td>NEDC</td>
<td>FTP 75</td>
<td>NEDC</td>
<td>JC 08</td>
</tr>
<tr>
<td>Planned emission test</td>
<td>WLTP / RDE</td>
<td>FTP 75</td>
<td>WLTP / RDE</td>
<td>WLTP</td>
</tr>
<tr>
<td>Implementation WLTP</td>
<td>Start in 09/17, Fully compliant 2020</td>
<td>No implementation planned</td>
<td>July 2020, RDE starts in July 2023</td>
<td>Start in 2018, Fully compliant 2022</td>
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<tr>
<td><strong>CO₂ targets [g/km]</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>130</td>
<td>158</td>
<td>161</td>
<td>142</td>
</tr>
<tr>
<td>2020</td>
<td>95</td>
<td>125</td>
<td>117</td>
<td>122</td>
</tr>
<tr>
<td>2025</td>
<td>97</td>
<td>99</td>
<td>97</td>
<td>122</td>
</tr>
<tr>
<td>2030</td>
<td>74</td>
<td>62</td>
<td>12</td>
<td>62</td>
</tr>
</tbody>
</table>

**Assumption:** +20% amount of tested CO₂ from NEDC to WLTP

**Figure 1. International comparison of test cycles**

**Note:** ICCT is source for CO₂ values per car normalised on NEDC (USA, Japan) and EU 2025/30

Sources for converting factor of +20% from NEDC to WLTP:
2. VDA 12/2016 “Position zur Umstellung von CO₂ basierten Steuer-/Incentive-Systemen auf WLTP”;
3. ICCT 01/2018 “The European Commission regulatory proposal for post-2020 CO₂ targets for cars and vans: A summary and evaluation”;
4. PA simulation 2018 based on vehicle portfolio 2021 and adjusting factor according to European Commission Report (1)
The industry is also facing a range of other challenges such as the development of autonomous cars, increasing demand for connected cars and the prospect of city bans for internal combustion engines. Then there’s the dramatic decline of diesel and the boom in SUV sales, meaning there are more heavy cars on the road, increasing emissions.

Looking further ahead, there will also be challenges when changes to emissions testing come into force for regulatory purposes.

The new Worldwide Harmonised Light Vehicle test procedure (WLTP) measures emissions during a more demanding drive cycle.

The laboratory test is closer to actual driving conditions and uses real driving data to reinforce results. The test will be the basis for EU emissions targets in 2025 and 2030. Our analysis suggests WLTP will mean car makers show an average increase to CO₂ emissions of 20 per cent.
This is the fourth year we have assessed car makers’ performance and the likelihood that they will meet their 2021 targets. This year’s rankings show small changes again, with eight out of the thirteen car markers forecasted to miss their targets, though some are getting closer by accelerating towards their 2021 targets relative to how fast they’ve gone in previous years.

The reality is that given the proximity of the 2021 deadline, and the lead-time needed to implement technical changes, there’s little they can do in time. However, car makers are already at work on technical upgrades to meet the 2025 and 2030 targets.

So, for now, they’re essentially running two parallel processes: working to build market share for new low emission models before 2021 while investing in the technology needed to meet future regulations until 2030.
Figure 3. Our benchmarking model is based on various inputs and inform three scenarios.
THIS YEAR’S RANKINGS
TIME IS RUNNING OUT

Our unique method of benchmarking examines manufacturers’ performance against their specific targets and evaluates the gap car makers will need to close by 2021.

Our forecasts are made up of an assessment of each manufacturer’s capability to reduce average fleet weight as well as to enhance their electrified portfolio. We also make forecasts of the number of registrations of each type of car (diesel, petrol, different types of hybrid and battery electric) to determine the extent of each manufacturer’s sales of lower emission vehicles.

This year, we have looked at sales of these vehicles by vehicle segment (from small to luxury cars) which has helped us make our forecasts more accurate. We then put this data together to develop our forecasts of average CO₂ (g/km) emissions in 2021.

We have also added forecasts for Mazda and Honda. A further development in our work has been to provide additional scenarios which show a range of performance based on optimistic or pessimistic assumptions about the number of alternative vehicles sold.

This year’s results show small changes in the rankings. Toyota is now at the top of the table followed by Renault-Nissan-Mitsubishi and Volvo. However, eight out of the thirteen manufacturers will miss their targets, although Daimler and BMW have improved their performance and are getting closer to complying.
## ACTUAL DATA (g CO₂/km)**

<table>
<thead>
<tr>
<th>RANK</th>
<th>CAR MAKER</th>
<th>2016</th>
<th>2017</th>
<th>2021 TARGET</th>
<th>2021 FORECAST</th>
<th>2021 AGGRESSIVE FORECAST</th>
<th>2021 CONSERVATIVE FORECAST</th>
<th>DEVIATION</th>
<th>DEVIATION</th>
<th>DEVIATION</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Toyota</td>
<td>105.5</td>
<td>103</td>
<td>95.1</td>
<td>87.1</td>
<td>-8</td>
<td>90.7</td>
<td>-4.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Renault-Nissan-Mitsubishi</td>
<td>111.2</td>
<td>112</td>
<td>94.8</td>
<td>92.1</td>
<td>-2.7</td>
<td>93.9</td>
<td>-0.9</td>
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<tr>
<td>3</td>
<td>Volvo</td>
<td>121.5</td>
<td>124.3</td>
<td>106.7</td>
<td>93.7</td>
<td>-13</td>
<td>100.3</td>
<td>-6.4</td>
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<tr>
<td>4</td>
<td>Honda</td>
<td>126.9</td>
<td>127.3</td>
<td>96.6</td>
<td>95.5</td>
<td>-1.1</td>
<td>98.5</td>
<td>1.9</td>
<td></td>
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<td>5</td>
<td>PSA</td>
<td>110.4</td>
<td>112</td>
<td>93</td>
<td>95.6</td>
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<td>97.1</td>
<td>4.1</td>
<td></td>
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<tr>
<td>6</td>
<td>Hyundai-Kia</td>
<td>124.7</td>
<td>122</td>
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<td>3.6</td>
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<tr>
<td>7</td>
<td>Mazda</td>
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<td>131.2</td>
<td>94.9</td>
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<td>100</td>
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</tr>
<tr>
<td>8</td>
<td>Fiat-Chrysler (FCA)</td>
<td>120</td>
<td>120</td>
<td>91.8</td>
<td>98.5</td>
<td>6.7</td>
<td>101.5</td>
<td>9.7</td>
<td></td>
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<tr>
<td>9</td>
<td>Ford</td>
<td>120</td>
<td>121</td>
<td>95.4</td>
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<td>101.9</td>
<td>6.5</td>
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<tr>
<td>10</td>
<td>Volkswagen</td>
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<td>122</td>
<td>97.7</td>
<td>101.5</td>
<td>3.8</td>
<td>103.3</td>
<td>5.6</td>
<td></td>
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<tr>
<td>11</td>
<td>BMW</td>
<td>122.9</td>
<td>122</td>
<td>102.4</td>
<td>104.4</td>
<td>2</td>
<td>106</td>
<td>3.6</td>
<td></td>
<td></td>
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<tr>
<td>12</td>
<td>Daimler</td>
<td>125.3</td>
<td>127</td>
<td>102.8</td>
<td>104.6</td>
<td>1.8</td>
<td>106.1</td>
<td>3.3</td>
<td></td>
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<tr>
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<td>Jaguar-Land-Rover</td>
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<td>151.4</td>
<td>130.6</td>
<td>130.1</td>
<td>-0.5</td>
<td>136.6</td>
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</table>

*rank on 2021 forecast **data from ICCT 2017 ***based on actual data until 2017 (ICCT) and PA forecast estimation
What this means is that some companies are likely to face significant fines. Volkswagen faces a potential penalty of 1.4 billion Euros (10 per cent of its 2017 earnings), reflecting the high number of cars they sell in Europe. PSA (including Opel/Vauxhall) could see fines of 600 million Euros, amounting to 20 per cent of its earnings in 2017, and Ford and Fiat Chrysler (FCA) could see penalties of 10 per cent of their earnings in 2017.

Our more optimistic scenario, where we assume higher sales of low emission vehicles, shows that only FCA and Ford would still miss their targets by a significant margin. The more pessimistic scenario, assuming lower sales, shows that Honda and Jaguar Land Rover will both miss their target as well, but the most important message of this analysis is that struggling companies will miss their targets by a greater margin, meaning higher penalties.

<table>
<thead>
<tr>
<th>CAR MAKER</th>
<th>DEVIATION IN 2021* (g CO₂/km)</th>
<th>PENALTY 2021* (in million €)</th>
<th>PENALTY 2021* in % of EBIT in 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volvo</td>
<td>-13.0</td>
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<td></td>
</tr>
<tr>
<td>Toyota</td>
<td>-8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renault-Nissan-Mitsubishi</td>
<td>-2.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honda</td>
<td>-1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jaguar-Land-Rover</td>
<td>-0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daimler</td>
<td>1.8</td>
<td>190</td>
<td>1%</td>
</tr>
<tr>
<td>BMW</td>
<td>2.0</td>
<td>200</td>
<td>2%</td>
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<tr>
<td>Hyundai-Kia</td>
<td>2.1</td>
<td>300</td>
<td>5%</td>
</tr>
<tr>
<td>PSA</td>
<td>2.6</td>
<td>600</td>
<td>20%</td>
</tr>
<tr>
<td>Mazda</td>
<td>3.2</td>
<td>75</td>
<td>8%</td>
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<tr>
<td>Volkswagen</td>
<td>3.8</td>
<td>1400</td>
<td>10%</td>
</tr>
<tr>
<td>Ford</td>
<td>4.4</td>
<td>430</td>
<td>10%</td>
</tr>
<tr>
<td>Fiat-Chrysler (FCA)</td>
<td>6.7</td>
<td>700</td>
<td>10%</td>
</tr>
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</table>

Figure 5. CO₂ performance and penalties expected
HOW CAR MAKERS PERFORM A VARIETY OF STRATEGIES

It’s clear that all the manufacturers are focused on increasing their portfolio of low emission vehicles and adopting a variety of approaches and strategies to do so.
Figure 6. CO₂ emission reduction over time against 2017 actual data and 2021 targets
TOYOTA MOTOR CORPORATION

Toyota is the global leader in hybrid technology and sold more than 1.5 million hybrid cars across the world in 2017. In the European market, it has two brands: Toyota and Lexus.

Our forecast shows its CO₂ emissions falling from 103g today to 87.1g in 2021, easily meeting its 95.1g target. The number of plug in hybrid vehicles (PHEV) sold in Europe is likely to remain under two per cent of its sales in 2021 but full-hybrid sales are likely to reach 72 per cent.

Toyota’s overall strategy for the next five years is to build the widest electrified portfolio with full hybrids in almost every market segment. It plans for every model to be available as an electrified version by 2025. The company will launch more than 10 different types of battery electric vehicles (BEV) in China by the early 2020s and these will gradually be introduced to Europe. The fuel cell electric vehicle (FCEV) line up will be expanded in both passenger and commercial vehicles in the 2020s and hybrid electric vehicle (HEV) technology will be developed further. In addition, Toyota will expand the number of PHEVs in the 2020s and aims to commercialise solid state battery technology by the mid-2020s.

The Toyota hybrid strategy means it will meet the 2021 target. At the same time, the hybrid market looks set to grow further as the vehicles become more affordable. However, Toyota lacks highly electrified options such as battery electric vehicles (none in the current line-up) and PHEVs (only one so far), and it will need these to meet the 2025 targets.

While it is investing in these technologies, and in fuel cell systems, it has not yet introduced them. However, its long experience in car electrification in the last two decades means it should be well placed to move towards full electrification.
The Renault-Nissan Alliance was created in 1999 and Mitsubishi Motors was added in 2016. It is currently the largest manufacturer of electric vehicles worldwide and sold more than half a million electric cars globally in 2017. In the European market, it has mainly low-cost and mainstream brands (Renault, Dacia, Nissan, Mitsubishi) as well as an emerging premium brand (Infiniti).

We forecast that its CO₂ emissions will fall from 112g today to 92.1g in 2021, meeting its 94.8g target. PHEVs and BEVs sold in Europe are forecast to make up 11 per cent of sales in 2021 with the share of BEVs alone possibly reaching eight per cent.

The Alliance has made huge investments in the research and development of its electrification and production systems. This has allowed it to both increase capacity in current plants and prepare new plants to produce EVs. The company also has significant experience in PHEV technology from the Outlander PHEV and can apply this technology to other vehicles and brands.

The Alliance’s strategy is to remain the global leader in affordable mass market EVs and it plans to invest one billion Euros in France between 2018 and 2020 to enhance EV production. It will launch 12 fully-electric models by 2022 while reducing battery costs by 30 per cent of their 2016 level. This should dramatically reduce the cost of small electric cars. Meanwhile, the Alliance aims to have a 600km EV range for large cars by 2022, and a 15-minute charge delivering a 230km range, up from 90km in 2016.

All this underlines that the Alliance has the expertise it needs to achieve its 2021 CO₂ target and the future emission targets for 2025 and beyond.
Volvo Cars is the only Swedish automotive manufacturer. It was taken over by the Chinese group Geely in 2010 and operates two brands: Volvo and the newly created Polestar.

We forecast that Volvo’s CO₂ emissions will drop from 124.3g today to 93.7g in 2021 and so should easily meet its 106.7g target. We expect the share of both PHEVs and BEVs sold will reach 21 per cent of its sales in Europe by 2021.

Its strategy for the next five years is that all new models will be electrified, and we assumed there will be no diesel options from 2023. The electrified portfolio will include MHEV, PHEV and BEV. The Polestar performance brand will only offer PHEV and BEV options, increasing the number of fully electric cars to five between 2019 and 2021 (three Volvos and two Polestars). The company aims to achieve 25 per cent pure electric vehicles by 2025.

Volvo is a frontrunner in the electrification race and is already selling a substantial proportion of highly electrified cars. It’s proved to be a very agile company that’s able to pick up the latest trends. With the help of its parent company, Volvo is now challenging electric car companies like Tesla with a focus on the premium segments. This means Volvo should not only easily meet its 2021 CO₂ target but is also well placed to meet the next set of EU regulations.
Honda Motor is a Japanese car manufacturer with one brand in Europe (Honda).

We forecast that its CO₂ emissions should drop from 127.3g today to 95.5g in 2021 and so will meet its 96.6g target. We expect the sales of PHEVs and BEVs sold in Europe to make up seven per cent of the total in 2021, though the share of full-hybrids may reach almost half of its sales.

Honda has committed to having electrified cars making up two thirds of its global sales by 2025 and for an electrified variant to be featured in every new model launched in Europe. The Honda Urban EV Concept will be the first mass-produced fully electric Honda from 2019.

Meanwhile the company is planning to launch its CR-V Hybrid in early 2019 in Europe.

Honda, along with Toyota, has pioneered hybrid technology, but has struggled to break into the European hybrid market. Its weakness in Europe could make it difficult to produce and sell fully electric cars both at an affordable price for customers and profitably for Honda.

However, if it gets the right approach it could quickly switch from an all conventional portfolio to a widely electrified portfolio and meet its 2021 target as well as those for 2025 onwards.
French company PSA Group is the second largest manufacturer in Europe. Its brands are: Peugeot, Citroen, DS, Opel/Vauxhall.

We forecast that its CO₂ emissions will fall from 112g today to 95.6g in 2021 but it will miss its 93g target. We predict that PHEVs and BEVs sold in Europe by PSA should reach around three per cent of its total sales in 2021.

Its acquisition of GM Europe (Opel/Vauxhall) has increased its challenge as these former GM cars are less efficient and have up to 30 per cent higher CO₂ emissions than the PSA equivalents. The priority is to switch from GM powertrains to PSA ones as soon as possible, a process which should be completed by 2024. PSA also plans to develop new modular platforms to integrate electrified powertrains and to launch 40 electrified models by 2025 with the first EV arriving in 2020. Eighty-six per cent of the main PSA models should be electrified by 2023 and 100 per cent of the Opel/Vauxhall line up by 2024.

The PSA Group has made limited progress in the electrification of its portfolio and the first models will only be available by the end of 2019 at the earliest. It does have the advantage that its sales volumes are concentrated on two market segments (small and compact cars) where emissions can be reduced by measures like mild-hybrid systems. However, these systems will not be introduced before 2022 making both the 2021 target and future ones challenging.
The Hyundai Motor Group, is the largest South Korean automotive manufacturer and has two mainstream brands in Europe: Hyundai and Kia. Our forecast shows its CO₂ emissions will drop from 122g today to 96.1g in 2021, meaning the company will struggle to reach its 94g target. The number of PHEVs and BEVs sold in Europe should reach 11 per cent of sales in 2021. Hyundai’s plans include launching 14 new all-electric models by 2025 and it’s developing a dedicated EV platform. EVs should account for about 10 per cent of their global vehicle sales by 2025, up from one per cent in 2016, and it plans 38 low emission models by 2025 (hybrid, PHEV, BEV, FCEV). Its focus remains on pioneering the development and sale of FCEV technology and it has an agreement with Audi, including the Volkswagen brand, to develop this work and share patents.

By sharing platforms among the different powertrains, the group is speeding up progress towards a full electrification of its brand portfolio. This has led to an improvement in its performance. Yet Hyundai still has a challenge in mass-producing affordable electrified cars. To reach the 2021 target will require it to speed up the launch and marketing of new electric cars. However, looking further ahead, it will be in a stronger position to meet future targets.
The Mazda Motor Corporation is a midsize Japanese car manufacturer which operates a single mainstream brand: Mazda.

The target for Mazda, like Jaguar Land Rover, includes special exemptions as its EU sales volumes are below 300,000 a year and its CO₂ emissions in 2007 were particularly high. Despite this, our forecast shows CO₂ emissions should drop from 131.2g today to 98.1g in 2021 and so it will struggle to reach its 94.9g target in 2021. We predict that PHEVs and BEVs will be less than six per cent of sales in 2021 but the share of full hybrids may reach 25 per cent.

Mazda’s investment in electrification is leveraged through a strategic partnership with Toyota. It aims to introduce new petrol and diesel cars using its SkyActiv technology which will reduce emissions by a potential 20 per cent for the petrol vehicles, thanks to the adaptation of diesel cycles to these engines. It will also launch MHEV and fully electric vehicles in 2019 and PHEVs after 2021.

Today it has no electrified option in its worldwide line-up and its global management is still strongly defending combustion engines because well-to-wheel emissions are not higher than EVs. However, the partnership with Toyota is enabling it to implement (at least partly) their hybrid technology in its own cars. Mazda could be agile enough to quickly switch from an all combustion engine approach to a widely electrified portfolio and be in a position to meet future regulations.
FIAT CHRYSLER AUTOMOBILE

The 2014 merger of the Fiat and Chrysler automotive groups created Fiat Chrysler Automobiles (FCA). Its main brands in Europe are: Fiat/Abarth, Alfa-Romeo, Jeep, and Maserati.

Our forecast shows that FCA’s CO₂ emissions will drop from 120g today to 98.5g in 2021 but it will still miss the EU target of 91.8g. This results from the relatively low share of PHEVs and BEVs, which we forecast to be about 6.5 per cent of its European sales in 2021.

The forecasts reflect FCA’s late start in the electrification transformation. Its core strategy is now to transform the sales structure of the group quickly to meet CO₂ targets and, over the next five years, it plans to phase out diesel in all passenger vehicles and invest nine billion Euros in electrification by 2022.

All FCA brands (including Alfa Romeo and Maserati) will be electrified by 2022 and Fiat will dramatically reduce its portfolio to focus on small and city cars with efficient petrol engines or full-electric powertrains, leaving only the Panda and 500 model range. The other Italian brands (Alfa Romeo and Maserati) are committed to achieving a large proportion of low CO₂ emission vehicles as soon as possible. The strategy is less clear for Jeep, as its customers are more price sensitive.

The challenge is that this strategy has been developed very late and FCA will only meet its CO₂ target by taking a big hit on profits to make low emission vehicles attractive to buyers. It will also need a consolidated sales and marketing activity to push these vehicles. Equally its focus on mild hybrids (combustion engines supported by electric motors) will not provide a long-term solution for meeting the next set of EU regulations.
Ford of Europe is the subsidiary company of Ford Motor Company which operates the Ford brand in Europe.

We forecast that its CO₂ emissions will drop from 121g today to 99.8g in 2021 but that will leave Ford well short of its 95.4g target. We predict that the number of PHEVs and BEVs sold in Europe will reach almost seven per cent of sales in 2021.

Ford plans to increase investment in electrification to $11 billion over the period to 2022. The investment will include the costs of developing a dedicated platform for electric vehicles, the launch of 16 fully electric models and the release of 24 PHEVs by 2022. This is backed up by the creation of Team Edison, which will identify and secure partnerships in e-mobility with car makers or suppliers, so far focusing on the US market.

Ford is a latecomer to electrification and only produced its strategy during 2018. It’s currently mainly selling small and compact cars, all of which have classical combustion engines. Hybrid car sales represented only 0.4 per cent of its overall European sales in 2016.

Despite its planned investment, it is unclear how quickly it can electrify the portfolio, as it’s starting from scratch and has almost no experience compared to its competitors. Technologically switching its product portfolio within such a short time will be a challenge.

One way Ford could speed up its advances towards electrification is by collaborating with other car makers. So, despite the challenges, Team Edison may be able to drive big transformations and quick decisions. Yet so far Ford has made no announcements about how it plans to meet its 2021 target for the European market.

Our view is, given the significant investment needed to meet stricter CO₂ requirements – in the context of Ford’s dependence on the combustion engine, delays in introducing hybrid and fully electric vehicles, and its currently low margins and profitability – it may have to consider the long-term strategy in Europe. As it stands it’s unlikely to meet its 2021 target.
VOLKSWAGEN

Volkswagen is the largest car manufacturer in the world and has eight brands in Europe (Volkswagen, Audi, Škoda, Seat, Porsche, Bugatti, Bentley and Lamborghini). Bentley and Lamborghini have specific EU targets and were excluded from the Volkswagen analysis.

We forecast that Volkswagen’s CO₂ emissions will drop from 122g to 101.5g in 2021, missing its 97.7g target by a significant margin. We predict that sales of PHEVs and BEVs in Europe will amount to eight per cent of Volkswagen’s total in 2021.

Volkswagen is now focusing on electrification and plans for 16 EV production sites to be in operation by the end of 2022. This is part of a €44 billion investment programme until 2023, covering new production sites, R&D for fully electric vehicles, autonomous driving and digitalisation in cars. The company will launch 80 electrified models (50 EVs and 30 PHEVs) by 2025 across all its brands and has a target of selling three million EVs a year globally by 2025 across the whole group.

Despite these ambitious plans, Volkswagen is coming to electrification late. Even though the portfolio now has a few PHEVs and the e-Golf is one of the best-selling fully electric cars in Europe, the sales trend has been towards SUVs with bigger engines and higher CO₂ emissions. However, Volkswagen is putting a lot of resources into electrification and this should help it meet the next set of emissions targets.
BMW GROUP

BMW Group is a German automotive manufacturer operating three premium brands: BMW, Mini and Rolls-Royce.

Our forecast shows its CO₂ emissions will drop from 122g today to 104.4g in 2021, bringing it closer to meeting its target of 102.4g. We expect PHEVs and BEVs to make up 13 per cent of its sales in Europe in 2021.

BMW’s strategy for the next five years is to build on its electrified portfolio to get PHEV or BEV options in almost every market segment. The original three-door Mini will be offered as a BEV next to conventional variants from 2019, a fully electric SUV iX3 will be launched in 2020 and the fully electric sedan iNEXT in 2021. By 2025 it plans to launch 25 electrified models (12 all-electric and 13 PHEV) and to have from 15 to 25 per cent electrified vehicles (PHEV or BEV) globally by 2025. It is also moving away from its traditional diesel development, as its US market exit from diesel shows.

BMW started early with electrification, but a slow start to the BEV market led it to pause its investment in the i-brand. Instead, BMW focused on plug-in hybridisation of all models and sold over 100,000 electric cars last year (PHEVs and BEVs). If it can increase PHEV and BEV sales it could achieve its 2021 target and be well placed to meet future post-2025 targets.
DAIMLER

Daimler is a German premium manufacturer operating Mercedes-Benz, Smart and EQ. We forecast its CO₂ emissions will fall from 127g today to 104.6g in 2021 and so narrowly miss its 102.8g EU target. We expect that the number of PHEVs and BEVs sold in Europe by Daimler will reach 13 per cent of sales in 2021.

Daimler’s plans include the launch of a new fully-electric brand called EQ to run in parallel with Mercedes-Benz, the result of a 10 billion Euro investment. It will have ten fully electric vehicles by 2022. The Mercedes-Benz portfolio is to be entirely electrified with PHEVs or at least MHEVs by 2022, with an overall electrified portfolio of about 50 models by 2022. It also plans to introduce FCEV technology from 2019 in an adapted Mercedes-Benz model.

Electrification has been at the heart of the Daimler strategy for a number of years and it has already built a logistics chain to enable it to mass produce pure electric vehicles as well as PHEV. It has also created the Accumotive subsidiary to develop and produce batteries for Daimler cars, as well as NuCellSys, a subsidiary to develop fuel-cell solutions for cars.

The challenge now is to convert these developments into sales and to deliver on its plans. Daimler postponed the commercial launch of its EQ-brand for six months – it’s now not due until mid-2019. Daimler will therefore struggle to meet its 2021 CO₂ target unless it can increase PHEV and EV sales. However, its full electrification plan puts it in a good position to meet future targets.
JAGUAR LAND ROVER

Owned by Tata Motors, Jaguar Land Rover Ltd has two premium brands: Jaguar and Land Rover. As it sells fewer than 300,000 cars a year in Europe, it has a specific emissions target of 130.6g and we forecast that CO₂ emissions should drop from 150g today to 130.1g in 2021. We predict that PHEVs and BEV sales in Europe should reach almost ten per cent of the total in 2021.

Its strategy is that every Jaguar and Land Rover model launched from 2020 will have an electrified option, including fully electric, PHEV and MHEV. It introduced its first mass-produced BEV in 2018. This was the first electrified SUV among established brands. It also launched its first PHEV this year.

Despite its higher emissions target, Jaguar needs to focus on electrification to be sure of reaching it, and to catch up with the other car makers in case they will not be able to benefit from exceptions from the emission targets in the future. Its challenge is that it’s dependent on other manufacturers, as with the I-Pace manufactured by Magna-Steyr in Austria.
WHAT CAR MAKERS CAN DO
THE NEXT THREE YEARS

Our results show that it’s too late for dramatic changes in technology or strategy to make a difference to manufacturers’ ability to meet the 2021 targets. However, progress is undoubtedly being made on electrification, many new models are being developed and a range of low emissions technologies have real potential to reduce CO₂ emissions further. The challenge for car makers is how quickly they can apply and sell them.

What matters in meeting the 2021 targets is timing. We can see this in the very different stories of Renault-Nissan-Mitsubishi and Fiat Chrysler. Renault Group focused early on affordable electrification and will meet their target. Fiat Chrysler came to the issue very late and have only just developed an electrification strategy and will miss the target.

A GOOD STORY
RENAULT-NISSAN-MITSUBISHI

- Early bird in the electrification process
- Zero-emission strategy
- Most successful manufacturer for pure electric cars
- Highest production capacity for electric cars
- Nissan Leaf to become almost as affordable as a conventional car (leasing)
No electrification strategy until June 2018
- Deep transformation in the brand portfolio
- Short-term development focused on mild-hybrid
- Electrification of high-value cars is coming late

“A BAD STORY: FIAT CHRYSLER AUTOMOBILE

Way towards zero emission fleet

2017 fleet emission level: 120g/km

2021 fleet emission level
- Worst case: 101.5 g/km
- Most likely case: 98.5 g/km
- Best case: 95.3 g/km

CO₂ target: 91.8g/km

“To pay the huge fine is not an option”
Fiat-Chrysler CFO
WHAT CAR MAKERS CAN DO
THERE ARE THREE KEY LEVERS

This underlines that those manufacturers at risk of missing their targets need to focus on sales, marketing and price. Only by increasing their sales of low emission vehicles will they be able to move towards the target and reduce their fines. That means focusing and understanding their sales volumes by CO₂ emissions, underpinned by marketing that really pushes hybrids and fully electrified vehicles.

There’s also the question of price. When it comes to electric vehicles, it will take until 2028 for them to cost the same as conventional petrol ones, so manufacturers may need to take the profit hit by providing price incentives to generate enough sales to make a difference.

Additional forces outside of the car markers’ control include the extent to which government incentives (around things like cost) and investment (in things like charging stations) encourage people to buy electric vehicles.
SALES
Steering sales volumes by CO₂ emissions

Sales steering needs to set up new processes to get sales data from car dealers all over Europe as fast as possible to adapt sales goals as well as production capacities in a very short time.

MARKETING
Pushing high electrified cars (PHEVs and BEVs)

Marketing must react quickly to adapt the commercial strategy to the needs of car makers in terms of high-electrified car sales and to reach their sales targets without exceeding them.

PRICING
Adapting price strategies and incentives

Adapting price strategies and incentives might be the best way to push electrified cars and reduce the gap to the CO₂ target. But to avoid a huge impact on profits, targets must not be exceeded.
WHAT CAR MAKERS CAN DO
THE MEDIUM TERM

The 2021 targets car makers must achieve are only the beginning of the emissions challenge. The EU is debating new targets for 2025 and 2030 and these are likely to be even more demanding. While no final agreement has been reached, the European Commission has proposed a 30 per cent reduction on 2021 levels to be achieved by 2030 with an intermediate step of a 15 per cent reduction by 2025.

However, the European Parliament has recently voted for even lower emission levels, aiming for a 40 per cent reduction by 2030 with an intermediate step of 20 per cent by 2025. The final agreement could be closer to a compromise of a 15 per cent reduction by 2025 and 35 per cent by 2030 (though this is still to be ratified at a national level). Furthermore, achieving targets will be made harder as future performance will be measured on the new test cycle which we estimate will increase CO₂ emissions by 20 per cent.

Electric vehicles will need to be cheaper than conventional ones

- We forecast cost parity for diesel and electric cars in 2020.
- We forecast cost parity for gasoline and electric cars in 2028.
- We forecast fuel cells to still be more expensive than other powertrains in 2030.
- We forecast BEVs will be cheaper than PHEVs and hybrid vehicles in 2021.
- Diesel has no or little CO₂ effect for lower middle class vehicles (C1-segment and below, e.g. Golf).
Assumptions:

• No change in material and labour cost until 2030, cost base 01/2016 (cobalt: $25/kg, crude oil: $28/barrel)
• Fuel Cell
  - Price degression based on volume and technology, tank and cell design (appr. 0.1% in 2020 1-3% in 2025 and >4-8% in 2030)
  - Range: 400-600 km
• BEV
  - Price degression based on volume and technology for Lithium Ion Battery (appr. 5% in 2020, 15-25% in 2025 and >30% in 2030)
  - range >400-600 km
  - Solid state battery start in 2025 will reach Lithium cost -20% with further degression based on volume
  • PHEV range: 50-80 km
  • Hybrid range: 2-5 km
  • Mild Hybrid (48V) Petrol: no electric driving feasible

100% is the cost of a gasoline vehicle from C-segment in 2016 as baseline.

Increases to raw material costs (e.g. cobalt) could delay cost parity with diesel until 2023-24
• BEV may not reach cost parity with gasoline

Figure 7. Cost curves over time for different engine types
The implications of this are significant. Current winners like Toyota may struggle as their hybrids are unlikely to be able to deliver further reductions on this scale. Equally, as a good performer, they will have an increased challenge in reducing emissions further from an already low level.

It is here that technology will need to meet ingenuity and manufacturers will have to innovate across everything they do. That starts with getting the product right by focusing on R&D, leveraging partnerships and using agile approaches.

Asian companies are especially well placed to succeed. Compared with their European rivals, they have greater expertise in areas of electronic battery and software development – critical components of next-generation automobiles.

But none of this will be possible without effective production systems and supply chains. Again, these will need investment in new technologies, skills and partnerships.

Finally, customer engagement, through marketing pricing and experience, needs to support technological developments.

While there is much manufacturers can do, they will also need a supportive external environment in which the infrastructure and regulation for electrification are in place and standardised. This can only be achieved through collaboration between industry and government.
### Driving Into a Low Emissions Future – Looking Beyond 2021

<table>
<thead>
<tr>
<th>CAR MAKER</th>
<th>HEV</th>
<th>PHEV</th>
<th>BEV</th>
<th>2017</th>
<th>2021*</th>
<th>Target 2021**</th>
<th>HEV*</th>
<th>PHEV*</th>
<th>BEV*</th>
<th>Pricing difference PHEV vs. conventional model***</th>
<th>Pricing difference EV vs. conventional model***</th>
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<tr>
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<td>95.6</td>
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<td>+70%</td>
<td>+100%</td>
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<tr>
<td>Daimler</td>
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<td>102.8</td>
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<td>○</td>
<td>+35%</td>
<td>+85%</td>
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<td>○</td>
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<td>104.4</td>
<td>102.4</td>
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<td>○</td>
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<tr>
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<td>96.6</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Mazda</td>
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<td>98.1</td>
<td>94.9</td>
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<td>○</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Jaguar Land Rover</td>
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<td>○</td>
<td>151</td>
<td>130.1</td>
<td>130.6</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>+20%</td>
<td>+75%</td>
</tr>
</tbody>
</table>

**HEV:** Hybrid electric vehicle (mild and full)  
**PHEV:** Plug-in hybrid electric vehicle  
**BEV:** Battery-electric vehicle  

*PA forecast  
**Based on forecasted fleet  
***Based on selected mid-size sedans; engine sizes comparable between PHEV and conventional models  

**MARKET SHARE:**  
○ VERY LOW (<0.5%)  
○ LOW (<2.5%)  
○ MID (<5%)  
○ HIGH (<25%)  
○ VERY HIGH (>25%)  

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**Source:** PA Research, ICCT, Jato Dynamics, EEA, Company websites

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Figure 8. Increasing sales of electric vehicles can play a part in reducing fleet emissions.
THE COUNTRY RESULTS
NORWAY STILL LEADS THE WAY

While many European countries have set out ambitions to reduce overall CO₂ emissions from transport, only Norway has seen a significant reduction over the past year. In other European countries, levels have stayed broadly the same or increased.

Norway has reduced emissions from 94.2g CO₂/km in 2016 to 83.6g CO₂/km in 2017. Sales of plug-in hybrids and electric vehicles continue to rise and accounted for 39.3 per cent of new car sales in 2017. Denmark was second but a long way behind. Its emissions were 108g CO₂/km, up from 106.8g in 2016, and plug-in hybrid and fully electric vehicles are only 0.6 per cent of the total.

The Netherlands saw an increase in emissions from 105.7g CO₂/km to 109g and a reduction in sales of plug in hybrid and fully electric vehicles to 2.7 per cent of total sales. The UK saw a small decline in performance from 119.9g CO₂/km to 120.8g but an increase in electric vehicles sales to 1.9 per cent. Sweden has a fairly high share of plug-in hybrid and fully electric vehicles at 5.2 per cent of sales but a high level of emissions at 121g CO₂/km, a slight improvement on last year.

In contrast, in Germany emissions are at 126.2g CO₂/km and plug-in hybrid and fully electric car sales are only 1.6 per cent of the total, though this is double last year’s sales. Switzerland remains the worst performer where emissions increased to 133.2g CO₂/km, although plug-in hybrid and fully electric vehicles sales increased to 2.7 per cent of the total.

The reasons for these results are complex, although Norway’s position does seem to reflect the focused public policy measures and incentives for electric vehicles. However, it is clear that in other countries policy makers face real challenges in developing actions that will reduce emissions further. Except in Norway, emissions have not really reduced and sales of plug in hybrids and fully electric vehicles remain a very small percentage of the total.
### Table: CO₂ Emissions from Cars in Selected European Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>CO₂ Emissions from Cars (g/km)</th>
<th>Gross Domestic Product (€) Per Capita 2017</th>
<th>Share of Premium Cars***</th>
<th>Direct PEV* Incentive/Grant (€)</th>
<th>PEV* % of New Cars 2016</th>
<th>PEV* % of New Cars 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td><img src="" alt="Norway CO₂ Emissions" /></td>
<td>66,319</td>
<td>36%</td>
<td>n/a</td>
<td>29.1%</td>
<td>39.3%</td>
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<td>Denmark</td>
<td><img src="" alt="Denmark CO₂ Emissions" /></td>
<td>49,951</td>
<td>13%</td>
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<td>0.8%</td>
<td>0.6%</td>
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<td>Netherlands</td>
<td><img src="" alt="Netherlands CO₂ Emissions" /></td>
<td>42,784</td>
<td>20%</td>
<td>n/a</td>
<td>5.9%</td>
<td>2.7%</td>
</tr>
<tr>
<td>France</td>
<td><img src="" alt="France CO₂ Emissions" /></td>
<td>35,282</td>
<td>13%</td>
<td>3,500 - 10,000</td>
<td>1.4%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Ireland</td>
<td><img src="" alt="Ireland CO₂ Emissions" /></td>
<td>62,512</td>
<td>15%</td>
<td>2,500 - 5,000</td>
<td>0.5%</td>
<td>0.7%</td>
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<tr>
<td>Italy</td>
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<td>28,359</td>
<td>19%</td>
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<td>0.2%</td>
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<td>Spain</td>
<td><img src="" alt="Spain CO₂ Emissions" /></td>
<td>25,096</td>
<td>17%</td>
<td>&lt;5,500</td>
<td>0.3%</td>
<td>0.6%</td>
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<tr>
<td>UK</td>
<td><img src="" alt="UK CO₂ Emissions" /></td>
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<td>32%</td>
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<td>Sweden</td>
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<td>&lt;5,800</td>
<td>3.6%</td>
<td>5.2%</td>
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<tr>
<td>Germany</td>
<td><img src="" alt="Germany CO₂ Emissions" /></td>
<td>39,425</td>
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<tr>
<td>Switzerland</td>
<td><img src="" alt="Switzerland CO₂ Emissions" /></td>
<td>71,319</td>
<td>35%</td>
<td>n/a</td>
<td>1.9%</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

*PEV includes both all-electric cars (BEV) and plug-in hybrids (PHEV)*

**Rank based on 2017 values**

***Top best selling cars of premium brands (C,D,E segment and SUVs)**

Sources: PA Research, EAFO, EU Pocketbook, Jato, ACEA, IMF

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**Norway:** In the course of the national transport plan Norway discusses to stop the admission from combustion engine driven cars beginning in 2025.

**Germany:** In the course of the “European strategy for emission free mobility” the german “Bundesrat” – Federal Assembly – has discussed that from the year 2030 no gasoline and diesel cars would be allowed any more to enter the market. A resolution is under discussion, nothing is decided yet.

**France/Netherlands:** Discussion about prohibition of ICE from 2040 currently ongoing.
MAKING PROGRESS BUT MORE TO DO

It has taken a long time for some car manufacturers to wake up to the challenge and the threat posed by the EU’s stringent emissions regulation. Most now have impressive plans in place but they should not underestimate the difficulty of changing from combustion engine cars to electric vehicles and the complexity and cost involved. They, and their suppliers, will need a very clear plan to guide them through the technical, operational, business and marketing changes ahead.

They also face the risk of new competitors entering the market. This is not just Tesla but new electric vehicle companies, possibly from China, who could challenge the whole EU car market with new electric vehicle options.

Policy makers should be thinking about the effect of new regulations on both the EU’s manufacturing base and on consumers. Car buyers are now very uncertain about what technology to invest in. Many are confused by the experience of policy changes on diesel and this could well make them less willing to embrace new electrification technology.

However, the car industry has always been a hugely innovative one that has been able to respond to challenges and with the right strategy it can prosper even in an uncertain future.
<table>
<thead>
<tr>
<th>DRIVERS</th>
<th>TYPICAL QUESTIONS</th>
</tr>
</thead>
</table>
| 1 PRODUCT | - What must the future brand / model / engine portfolio look like?  
- Which R&D competencies will be decisive in the future?  
- Which partnerships bring additional speed?  
- How can the development process be more agile and the development cycles be shortened? |
| 2 CUSTOMERS | - How can the multichannel approach be best used?  
- How can the customer experience of e-mobility be improved significantly?  
- What is the optimal pricing strategy?  
- What sales approaches and competencies are required for selling e-mobility products? |
| 3 SUPPLY CHAIN | - How can new engine technologies be integrated into existing plant footprint?  
- Which competencies are required for the future supply chain?  
- What can strategic suppliers and partners contribute?  
- How can the procurement of specific raw materials be ensured? |
| 4 EXTERNAL FACTORS | - Which activities support the expansion of e-mobility infrastructure?  
- How can standardisation and the introduction of technical standards be advanced?  
- How can acceptance and sales be further enhanced with government and industry cooperation? |
METHODOLOGY

We used the following approach to forecast car manufacturer’s CO₂ emissions.

Manufacturer specific CO₂ targets depend on the average fleet weight of each car maker and the difference from the average fleet weight of registered cars in Europe in the previous three years. We forecasted the average fleet weight of each manufacturer using a PA assessment of present and previous weight trends as well as the capabilities of car makers to reduce weight, and their commitment to enhance their electrified portfolio in the coming years.
We also calculated the respective number of registrations of each powertrain type and each car segment (city car, small car, compact car, SUV versions etc) for each manufacturer using an extrapolation of current trends and PA market insights into the future focus of individual car makers.

Our forecasts also reflect an assessment of the reductions in CO₂ emissions each manufacturer will see from developing different powertrain types, such as traditional internal combustion engines (ICE, e.g. diesel or petrol), mild-hybrid (MHEV), full-hybrid (HEV), plug-in hybrid (PHEV), battery electric (BEV) and other alternatives (natural gas etc). We expect that ICE CO₂ emissions will drop by 0.5 per cent to two per cent each year.
The specific CO₂ emissions performance reflects a segmented portfolio based on the actual and previous models as well as future trends and planned releases for each of the car makers. The portfolio segmentation was set up to discriminate between different powertrain types and car segments to better forecast the future evolution of CO₂ fleet emissions by each manufacturer.

This process allowed us to make forecasts regarding the development of different powertrain technologies such as hybrid, plug-in hybrid and electric powertrains by each car maker, as well as the extent of in heavy SUVs in their portfolio. Super-credits, which are awarded to each low emission registered vehicle (less than 50g CO₂/km), were also included in our forecasts.

The calculation of fines that the manufacturers will have to pay in case their average fleet emissions exceeds their target as of 2021 is based on the deviation between the emission level they will most likely achieve and their forecasted target. For each gram of CO₂ above the target car makers will be charged 95€ per car registered in the European Union.

Our 2021 forecasts are based on the NEDC test procedure as this will remain in place for 2021 CO₂ targets even though the WLTP test procedure has been phased in as information for consumers for all new registered cars in Europe since September 2018.
### Target Calculation

<table>
<thead>
<tr>
<th>General rule for every car maker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO₂ target:</strong> 95g/km as mean value adapted with fleet weight: from 90 to 110g/km</td>
</tr>
<tr>
<td>As a comparison, the today mean value is 118g/km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If sales &lt;300,000 units on demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO₂ target:</strong> -45% from the 2007 emission level</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If sales &lt;10,000 units on demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO₂ target:</strong> no general rule</td>
</tr>
</tbody>
</table>

### Regulations Framework

| **In 2020:** 95% of new passenger cars must comply with the specific limit for each car maker |
| **As of 2021:** 100% of new passenger cars |

### Awarded Super-Credits

<table>
<thead>
<tr>
<th>Each low-emitting car (&lt;50g/km) is counted as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 2 vehicles in 2020</td>
</tr>
<tr>
<td>- 1.67 vehicles in 2021</td>
</tr>
<tr>
<td>- 1.33 vehicles in 2022</td>
</tr>
<tr>
<td>- 1 vehicle from 2023 onwards</td>
</tr>
</tbody>
</table>

### Penalties

| 95 €/gram CO₂ over the target for each car registered in the EU |
About PA.

An innovation and transformation consultancy, we believe in the power of ingenuity to build a positive human future in a technology-driven world.

As strategies, technologies and innovation collide, we turn complexity into opportunity.

Our diverse teams of experts combine innovative thinking and breakthrough technologies to progress further, faster. Our clients adapt and transform, and together we achieve enduring results.

We are over 2,600 specialists in consumer, defence and security, energy and utilities, financial services, government, healthcare, life sciences, manufacturing, and transport, travel and logistics. And we operate globally from offices across the Americas, Europe, the Nordics and the Gulf.

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