Emissions from manufacturing in the autos sector: discussion paper

December 2025

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Acknowledgements

The views in this report are those of the authors and do not necessarily represent those of the host institutions or funders. The authors declare no conflict of interest in preparing this report. For the full disclaimer about the data and information published in this report, see p.18.

Suggested citation: Hastreiter N, Begley A and Dietz S (2025) *Emissions from Manufacturing in the Autos Sector*. London: TPI Global Climate Transition Centre, London School of Economics and Political Science.

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[1] This figure is subject to market-price and foreign-exchange fluctuations and, as the sum of self-reported data by TPI supporters, may double-count some assets.

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Executive Summary

This discussion paper examines the role of production emissions – specifically those arising from materials and manufacturing – in car manufacturers' carbon footprints and emissions reduction targets. The current Transition Pathway Initiative (TPI) Carbon Performance (CP) methodology for the automotive sector focuses on tailpipe (Scope 3 Category 11) emissions, which remain the largest contributor to lifecycle emissions for internal combustion engine vehicles (ICEs). However, as the industry shifts toward electric vehicles (EVs), a growing share of emissions is associated with upstream activities, including vehicle and battery production.

The paper identifies substantial gaps and inconsistencies in how car manufacturers disclose manufacturing-related emissions. While most companies report Scope 1 and 2 emissions – covering direct and energy-related emissions from their own operations – at a group level, data on Scope 3 Category 1 emissions, which cover upstream supply chain activities, is sparse and inconsistent. Disclosure specific to passenger cars is even rarer. This limited data availability poses challenges for external stakeholders seeking to assess companies' full emissions profiles and decarbonisation strategies.

To address this, the paper proposes a preliminary approach to incorporate production emissions into TPI's current CP methodology. Using IEA global average emissions factors and sales data for four major manufacturers – BMW, General Motors (GM), BYD, and Tesla – the analysis shows that including production emissions in companies' historical carbon footprints and decarbonisation targets leads to a deterioration in alignment with low-carbon scenarios, particularly over the long term.

These findings underscore the materiality of production emissions to car manufacturers' decarbonisation strategies. They also highlight the narrowing gap between mixed ICE/EV producers and pure EV companies when upstream emissions are considered. A narrow focus on tailpipe emissions therefore may not comprehensively capture companies' climate actions. The paper concludes with recommendations for investors to engage with companies to improve disclosure, support standardised reporting, and encourage comprehensive target-setting that includes production emissions.

1. Introduction

Shifting car sales from Internal Combustion Engines (ICEs) to Electric Vehicles (EVs) is essential to decarbonise the transport sector. In 2023, 1 in 5 cars sold worldwide was an EV, with the majority of these sales in China, the USA and Europe (IEA, 2024). National and supranational policies aim to maintain this trajectory. For instance, China's government has set a target to ensure EVs account for 45% of total car sales by 2027 (China State Council, 2024). Similar EV targets exist in the United States of America (USA) and European Union (EU); 50% of total car sales by 2030 (US Department of Transport, 2021)[2] and 100% zero emission vehicle sales by 2035 (European Commission, 2022), respectively.

From a life-cycle perspective, ICEs and EVs have markedly different emissions profiles. For ICEs, the bulk of value chain emissions arise in the use phase when fuel is combusted in the engine. In contrast, EVs are typically assumed to have zero emissions during the use phase. Instead, most of their lifecycle emissions stem from production and assembly processes.

Since ICEs still account for the large majority of new passenger car sales (IEA, 2024), the Transition Pathway Initiative's (TPI) Carbon Performance (CP) methodology for the automotive sector focuses on tailpipe emissions. In this framework, car manufacturers' primary lever for reducing emissions from their sold vehicles (Scope 3 Category 11) and thus to align with different decarbonisation scenarios is to shift their sales towards EVs. Box 1 provides a concise overview of TPI's current CP methodology.

Yet, as EV sales increase, it is worth examining whether emissions from car manufacturing could have a material impact on companies' alignment with decarbonisation scenarios. The shift towards EVs changes the emissions profile of car manufacturers by moving a greater share of their lifecycle emissions upstream. Not including emissions from manufacturing risks therefore overlooking a significant portion of companies' carbon footprints and may hinder accurate comparisons of decarbonisation efforts. This discussion paper explores these questions by analysing the availability of data on automotive manufacturing emissions and how these could be incorporated in TPI's CP assessments.

[2] On January 20th 2025, President Donald Trump signed Executive Order 14154, titled "Unleashing American Energy." The executive order aims to repeal the policy.

Box 1: The TPI Carbon Performance methodology for the automotive sector

TPI's CP methodology for the automotive sector was first developed in 2018 and focuses on emissions from the use phase of vehicles, which account for approximately 75% of a conventional ICE vehicle's lifecycle emissions.

In line with all TPI analyses, the methodology assesses company performance using publicly available data. In the automotive sector, this includes company disclosures as well as information from regulatory databases, such as the Monitoring of CO2 emissions from passenger cars Regulation provided by the European Environment Agency for Europe, National Highway Traffic Safety Administration (NHTSA) data for the United States, and Official Chinese Vehicle Consumption Statistics Annual Reports for China. The information required to establish a CP pathway includes emissions intensities for the jurisdictions in which a company sells passenger cars, sales in each of these markets and if applicable, targets for future emissions.
To ensure comparability across regions, we harmonise use-phase emissions intensities by converting different regional test cycles into a single standard (the Worldwide Harmonised Light Vehicle Test Procedure, WLTP) using conversion factors from the International Council on Clean Transportation (ICCT). We then calculate a sales-weighted average emissions intensity for each company.

TPI tracks both historical and current emissions intensities, and estimates forward-looking intensities based on the carbon reduction targets companies set. These company-specific pathways are then compared against sectoral decarbonisation benchmarks derived from International Energy Agency (IEA) scenarios, allowing us to assess companies' alignment with global climate goals. The scenarios, in order of ambition, are: 1.5 Degrees (1.5DS), Below 2 Degrees (B2DS) and National Pledges (NPS). Companies whose emissions intensities are above all these scenarios are scored "Not aligned". Companies that do not publicly disclose enough relevant information to establish a CP pathway receive a score of "No or unsuitable disclosure".

Further detail on TPI's current CP methodology for the automotive sector can be found here and company-specific assessment results can be viewed and downloaded here.

2. Limited and inconsistent disclosure on automotive manufacturing emissions

Manufacturing emissions in the automotive sector come from a wide range of sources due to a complex supply chain that is dependent on multiple economic sectors (Giampieri et al, 2020). Most upstream activities – including the extraction and processing of raw materials such as steel, aluminium and battery minerals – fall within car manufacturers' Scope 3 Category 1 (Purchased Goods and Services), as these processes are carried out by suppliers. In contrast, Scope 1 and 2 emissions cover only the direct and energy-related emissions from a manufacturer's own operations, such as vehicle assembly plants. However, the boundary between these scopes varies across companies because many manufacturers outsource substantial portions of component production and even final assembly. Firms with more outsourced production therefore report a greater share of manufacturing emissions in Scope 3 Category 1, while more vertically integrated firms report proportionally more in Scopes 1 and 2. Given this variation and the fragmented nature of automotive value chains, total upstream emissions from manufacturing can be significant and are often not fully reflected in manufacturers' disclosures.

While reporting of tailpipe emissions is well established in regulatory databases across the world, this is not the case for manufacturing emissions. Most companies report absolute Scope 1 and 2 emissions at a group-wide level, but specific figures for the production of passenger cars are rarely disclosed. Reporting on Scope 3 Category 1 is even more limited, with inconsistent coverage across geographies and business units.

Table 1 illustrates how eleven large international car manufacturers report production emissions across different scopes, both on a company level and specifically for passenger car production. Among the companies listed, the majority report on Scope 1 and 2 emissions company-wide. Nissan and Volkswagen disclose Scope 1 and 2 emissions specifically for passenger car production. Whilst BMW, Ford, GM and Volkswagen report Scope 3 Category 1 emissions at the corporate level, only BMW and Volkswagen report Scope 3 Category 1 emissions specific to passenger cars.

Some manufacturers also provide model-specific lifecycle emissions in their disclosures, although this remains uncommon. A broader, though non-exhaustive, range of model-specific lifecycle emissions data is accessible through third-party providers, such as the Green New Car Assessment Programme (Green NCAP).

Table 1 – Coverage of automotive sector emissions by Scope in manufacturers' public disclosures.[3]

Company	Scope 1 and 2 company wide	Scope 1 and 2 Production Emissions (Passenger Cars)	Scope 3 Category 1	Scope 3 Category 1 (Passenger car-specific)
BMW	Yes	No	Yes	Yes
BYD	Yes	No	No	No
Ford	Yes	No	Yes	No
GM	Yes	No	Yes	No
Mazda	Yes	No	No	No
Nissan	Yes	Yes	No	No
Renault	Yes	No	No	No
Suzuki	Yes	No	No	No
Tesla	No	No	No	No
Toyota	Yes	No	No	No
Volkswagen	Yes	Yes	Yes	Yes

Figure 1 reports a selection of available manufacturing emissions intensities for ICEs and EVs from various sources. Scope 1, 2 and 3 Category 1 emissions are included and the intensity metric is grams of CO_2e per kilometre (gCO_2e/km), as this is also the metric used in TPI's current CP methodology.[4] Alongside company- and model-specific emissions intensities, we include global and regional average intensities from IEA (2023) and ICCT (2021). The key result is that production emissions are significantly higher for EVs than ICEs. For example, the IEA's global average is 50 gCO_2e/km for EVs and 33 gCO_2e/km for ICEs.

Figure 1 also shows substantial variation within the ICE and EV categories. First, ICCT averages show notable regional differences, with higher emissions in Europe and India compared to China and the USA for both vehicle types. While outside the direct scope of this research, the ICCT report identifies several factors that may contribute to these regional differences.[5] These include the carbon intensity of electricity used in vehicle and battery manufacturing (particularly relevant for BEVs), regional battery supply chains, differences in vehicle and battery size, and production energy efficiency. For example, the concentration of European vehicle and battery manufacturing in countries with relatively high grid carbon intensity may help explain Europe's higher figures, while the smaller batteries typically used in Chinese BEVs may contribute to China's lower BEV figure.

Second, there are striking discrepancies between the IEA and ICCT global/regional averages and model- or company-specific disclosures. Interestingly, company estimates tend to be significantly higher. This may reflect differences in accounting boundaries, life-cycle assumptions or data quality. Third, estimates differ within the same company between NCAP and company disclosures, although this may be due to differences in the assessed models of car.

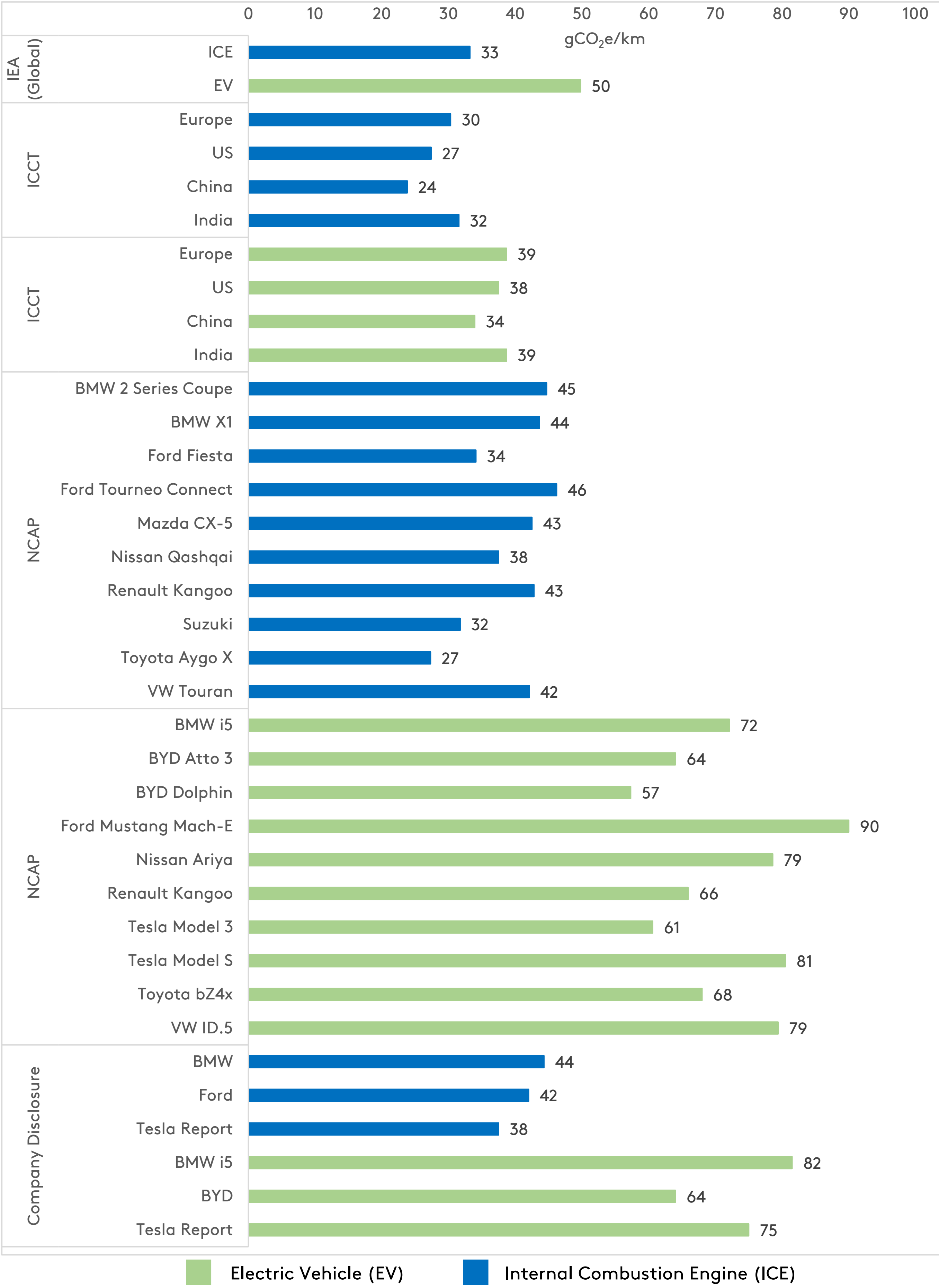
Taken together, these discrepancies point to methodological inconsistencies in the calculation of manufacturing emissions. The lack of standardisation remains a key barrier to systematically assessing production emissions in the automotive sector.

[3] Based on public disclosure available during the 2024/2025 CP assessment cycle.

[4] For Scope 1, 2 and 3 Category 1 emissions, this approach involves using an average mileage over a car's lifespan to convert production emissions per vehicle into emissions per kilometre driven. For this calculation, we apply the 200,000 km ratio disclosed in IEA (2023).

[5] The ICCT's regional figures are normalised using region-specific assumptions about lifetime vehicle mileage, which affects the per-kilometre production intensity.

Figure 1 – EV and ICE manufacturing emissions factors from various sources.



3. A preliminary approach to incorporating manufacturing emissions into TPI's CP methodology

As a preliminary investigation into the impact of including manufacturing emissions on automotive companies' CP, and in view of the inconsistencies in manufacturers' own disclosures, we use IEA global averages to adjust the sector-specific Scope 3 Category 11 benchmarks and company pathways from our current methodology. This approach is limited, as it does not account for variation in manufacturing emissions across companies. As shown in Figure 1, the global averages tend to lie below company-specific values. This suggests the method may yield a conservative estimate of the impact of manufacturing emissions on companies' alignment with decarbonisation scenarios.

3.1 Benchmarks

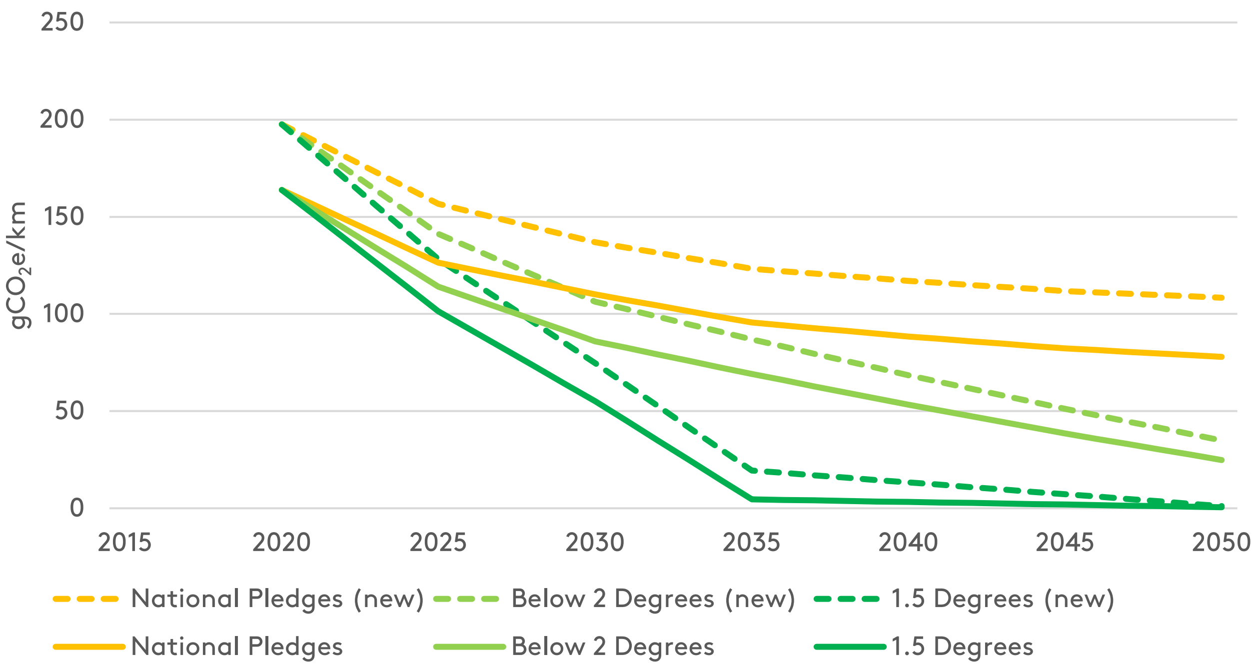
We begin by incorporating manufacturing and materials emissions into our sectoral benchmarks, which currently only include emissions from vehicle use. TPI assesses companies against three decarbonisation scenarios: 1.5DS, B2DS, and NPS.

First, we use the average manufacturing emissions factors from the IEA, i.e., 50 gCO_2e/km for EVs, 33.20 gCO_2e/km for ICEs and the average of the two, 41.50 gCO_2e/km, for Plug-in Hybrid Electric Vehicles (PHEVs). Then, we obtain IEA projections of the future sales mix to estimate the number of ICEs, EVs and PHEVs produced in each scenario (Global Electric Vehicle Outlook 2021, 2022). Subsequently, we calculate the scenario-specific weighted average emissions intensity for manufacturing and materials emissions. To do this, we multiply the aforementioned emissions factors by the sales share of each vehicle type in a given year. For instance, in 2020, EVs account for 3% of sales in the NPS scenario. Therefore, the calculation is 50 gCO_2e/km multiplied by 3%. To complete the benchmark value for 2020 in this scenario, we add the ICE and PHEV values. These are the relevant emissions factors multiplied by 96% and 1%, respectively.

Additionally, it is important to account for potential reductions in manufacturing emissions over time and changes in the total distance travelled by passenger cars. To adjust the benchmarks for scenario-specific reductions in production emissions, we apply the methodology outlined in TPI's *Other Industrials Discussion* paper (2021). Specifically, we adjust the numerator (production emissions) using scenario-specific residual industry emissions degrowth rates. To reflect changes in the total distance driven by new passenger cars, we adjust the denominator (km driven by new passenger cars) using the IEA scenario-specific growth rate in total car sales.

These steps give us carbon intensities from production emissions, which we add to the Scope 3 Category 11 benchmarks in our current methodology. Figure 2 shows the resulting upward shift across all scenarios. Unsurprisingly, the effect becomes negligible for the 1.5DS scenario in the long run, as both production and use-phase emissions go towards zero. The B2DS and NPS scenarios show a more sustained impact from the inclusion of production emissions.

Figure 2 – Automotive sector benchmarks including manufacturing and materials compared to current TPI CP benchmarks using only Scope 3 Category 11 emissions.



3.2 Companies' current and historical emissions

Given the inconsistencies in Scope 3 Category 1 reporting, we cannot rely on company disclosure. For this illustrative research, we apply instead the aforementioned global average production emissions intensities for ICEs, EVs and PHEVs to individual car manufacturers. Specifically, we identify the proportion of a company's new passenger car sales from EVs, ICEs and PHEVs in a given year from company disclosure. Then, we multiply these shares by the respective average emission factors for manufacturing and materials.

For example, if a company sells 80% ICE and 20% EV passenger cars in a specific year, the emissions intensity from manufacturing and materials is calculated as 33.2 * 0.8 + 49.8 * 0.2 = 36.52 gCO_2e/km for that year. This intensity is then added to the Scope 3 Category 11 intensity calculated using our existing methodology.

3.3 Companies' carbon emission reduction targets

For Scope 3 Category 11 emissions, car manufacturers typically set targets to reduce the emissions intensity of sold vehicles. This aligns well with our methodology, as these reductions can be directly applied to the historical carbon intensities we calculate for companies. In contrast, targets for production emissions are less compatible with our current approach. Initial research suggests that manufacturers primarily set targets for absolute Scope 1 and 2 emissions, while comprehensive targets including Scope 3 Category 1 emissions are rare. This poses a challenge, as we need to make assumptions about the share of upstream production emissions that should remain constant due to not being covered by the targets.

To address incomplete target coverage, we convert companies' absolute Scope 1 and 2 emissions into emissions intensities using total car sales and the IEA's assumption of 200,000 km as the total lifetime travel per passenger car. For example, if the company in the previous section reported combined Scope 1 and 2 emissions of 700,000 tCO_2e and sold 1,000,000 vehicles in 2021, its Scope 1 and 2 emissions intensity would be calculated as follows:

- 700,000 tCO_2e / (1,000,000 cars sold * 200,000km) = **3.5 gCO_2e/km**.

Using this intensity, we estimate the company's Scope 3 Category 1 upstream production emissions for 2021 as:

- 36.52 gCO_2e/km – 3.5 gCO_2e/km = **33.02 gCO_2e/km**

Next, we calculate the targeted Scope 1 and 2 emissions intensity. Assuming the company aims to reduce its Scope 1 and 2 emissions intensity by 50% by 2030 compared to 2021, the targeted Scope 1 and 2 emissions intensity would be:

- 3.5 gCO_2e/km * 0.5 = **1.75 gCO_2e/km**

We then add this targeted 2030 Scope 1 and 2 emissions intensity to the Scope 3 Category 1 intensity, which we assume remains constant from 2021 as it is not covered by the target:

- 1.75 gCO_2e/km + 33.02 gCO_2e/km = **34.77 gCO_2e/km**

Finally, we combine this targeted production emissions intensity with the targeted intensity for end-use emissions to calculate the company's overall emissions intensity for 2030.

4. The potential impact of production emissions on companies’ alignment with decarbonisation scenarios

To explore the potential impact of production emissions on companies’ alignment with low-carbon scenarios, we applied the preliminary methodology outlined in the previous section to four companies: BMW, GM, BYD and Tesla. This selection includes two manufacturers that produce both ICEs and EVs (BMW and GM) and two that exclusively produce EVs (BYD and Tesla). Companies were asked to provide feedback on the accuracy of the information.

These assessments are preliminary, and in a wider sample, assumptions could be necessary to estimate the granular sales split between EVs, PHEVs, and ICEs. For BMW, BYD, GM, and Tesla, granular splits were available for at least the past three years from their disclosures.

We then analysed the four companies’ emissions reduction targets:

- BMW has a target to reduce Scope 1 and 2 emissions by 46.3% by 2030 and Scope 3 Category 1, 4 and 11 emissions by 27.5% by 2030 compared to a 2019 base year. We apply these reductions proportionally. Moreover, the company discloses a target to reduce emissions by 90% across the value chain by 2050 compared to a 2019 base year. This target covers Scopes 1, 2, 3 (Category 1 and 11).
- GM has a target to reduce Scope 1 and 2 emissions by 72% by 2035, relative to 2018. For this assessment, we applied the methodology described in the previous subsection to calculate the impact of this target. We find that Scope 1 and 2 emissions account for approximately 10% of GM’s total production emissions. The remaining 90% are assumed to remain constant.
- BYD does not publish granular sales splits for years prior to 2020. Hence, historical carbon intensities could only be calculated from 2021 onwards. BYD does not publicly disclose forward-looking targets covering Scope 1, 2 and 3 emissions.
- TPI found no publicly disclosed emissions reduction target for Tesla.

Figure 3 illustrates the companies' final emissions intensity pathways, incorporating production emissions, compared with the benchmarks. In contrast, Figure 4 presents the same pathways using TPI's current methodology, which excludes production emissions.

Figure 3 – Preliminary company assessments including Scopes 1 and 2, and Scope 3 Categories 1 and 11 emissions.

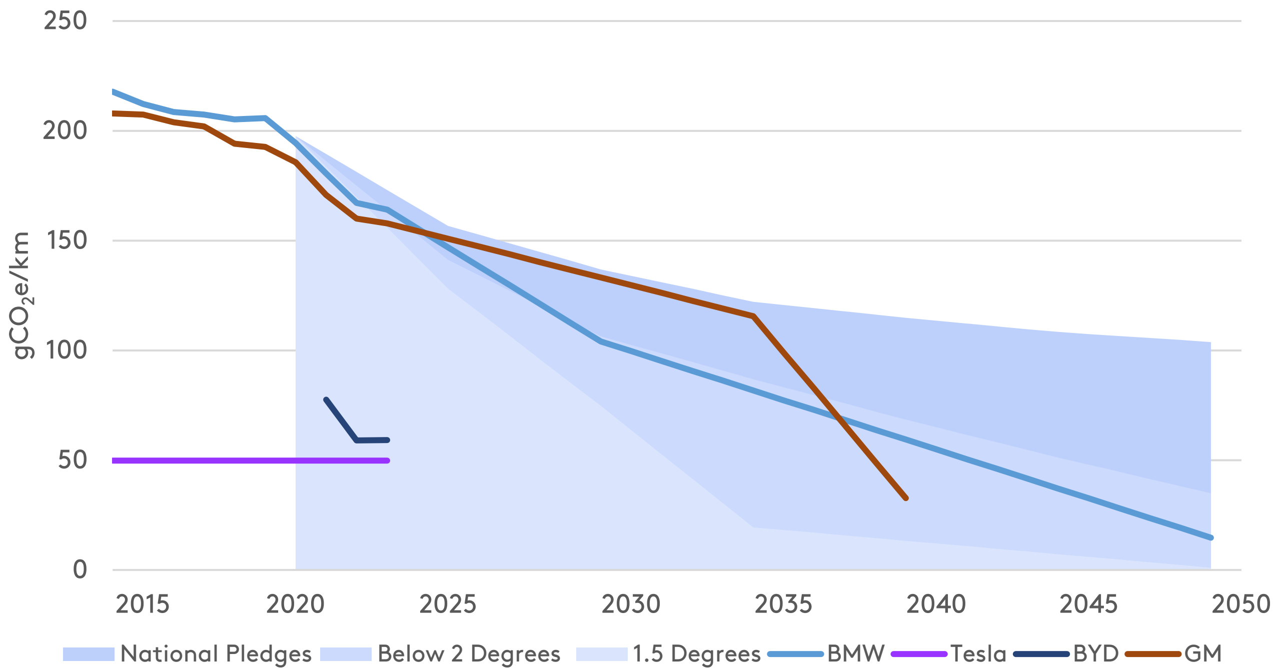
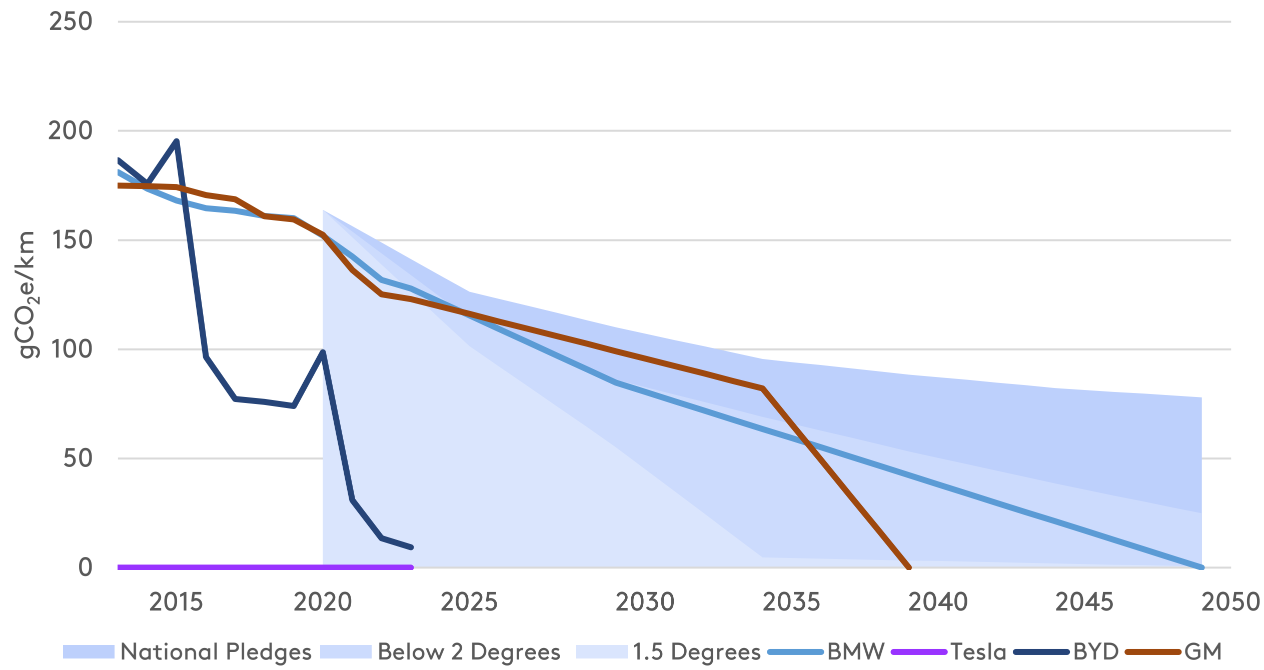


Figure 4 – Existing company assessments including only Scope 3 Category 11 emissions.



The inclusion of emissions from materials and manufacturing leads to an upward shift of all companies' pathways. The impact on companies' alignment is somewhat varied, as summarised in Table 2. For producers of both ICEs and EVs, including these emissions moves their alignment from 1.5DS to B2DS alignment in the long term. Whilst their Scope 3 Category 11 emissions decline as their EV production expands, Scope 1, 2 and 3 (Category 1) emissions do not decline as significantly. For BMW, their short-term alignment changes from B2DS to NPS. For pure EV producers, the adjustment does not affect short-term alignment. However, the long-term effect of incorporating emissions from manufacturing and materials is more pronounced as it makes long-term alignment less ambitious, moving BYD and Tesla to an NPS scenario, as shown in Table 2. In the medium term, Tesla moves from 1.5DS to B2DS, while there is no change for BMW, BYD and GM.

Overall, once manufacturing emissions are factored in, the differences between mixed ICE/EV and pure EV manufacturers become less distinct. While pure EV manufacturers continue to perform better based on alignment scores in the short and medium-term, long-term alignment scores vary. These findings highlight that inaction on manufacturing emissions could have a significant effect on car manufacturers' long-term decarbonisation plans.

Table 2 – Changes in companies' alignment scores based on the preliminary assessments.

Company	Short term (2028)	Medium term (2035)	Long term (2050)
BMW	Below 2 Degrees -> National Pledges	No change	1.5 Degrees -> Below 2 Degrees
BYD	No change	No change	Below 2 Degrees -> National Pledges
GM	No change	No change	1.5 Degrees -> Below 2 Degrees
Tesla	No change	1.5 Degrees -> Below 2 Degrees	1.5 Degrees -> National Pledges

5. Implications for investors

Our preliminary research shows that emissions reporting on production of vehicles is in its early stages. Figures disclosed across different sources are highly inconsistent, which poses a challenge in calculating an accurate emissions profile for car manufacturers. We hope to see advances in this space as the sector moves forward in the low-carbon transition.

Among production emissions, car manufacturers report and set targets primarily for Scopes 1 and 2. Yet, these likely account for a minority of total production emissions. Given the sector's fragmented value chain, upstream emissions from car manufacturers' suppliers are significant. Increased monitoring of emissions from car manufacturers' upstream value chain may be needed.

The key take-away from our illustrative analysis is that manufacturing emissions are material to automative companies' decarbonisation plans. As outlined above, emissions from manufacturing can have a material impact on companies' forward-looking decarbonisation pathways. As shown in Figure 3, when emissions from manufacturing are included, the difference between companies that produce both ICEs and EVs and those that only produce EVs becomes less clear. The primary driver of the decarbonisation of the automotive sector remains a shift towards EVs, which will reduce emissions from vehicles' use phase. Nevertheless, to reach net zero across the whole value chain, automotive companies will also need to reduce production emissions.

6. Recommendations for investors

Investors could consider the following actions to address production emissions in the automotive sector:

- **Engage with companies**: Advocate for comprehensive disclosure of manufacturing emissions, including Scope 1, Scope 2 and Scope 3 Category 1 emissions.
- **Support standardised reporting guidelines**: Promote the development of consistent reporting standards for the sector, ensuring clarity on scope and detailed breakdowns (emissions from passenger cars, heavy-duty vehicles, etc.).
- **Encourage target-setting**: Encourage companies to establish emissions reduction targets that comprehensively cover production emissions, including those from upstream value chain activities.

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