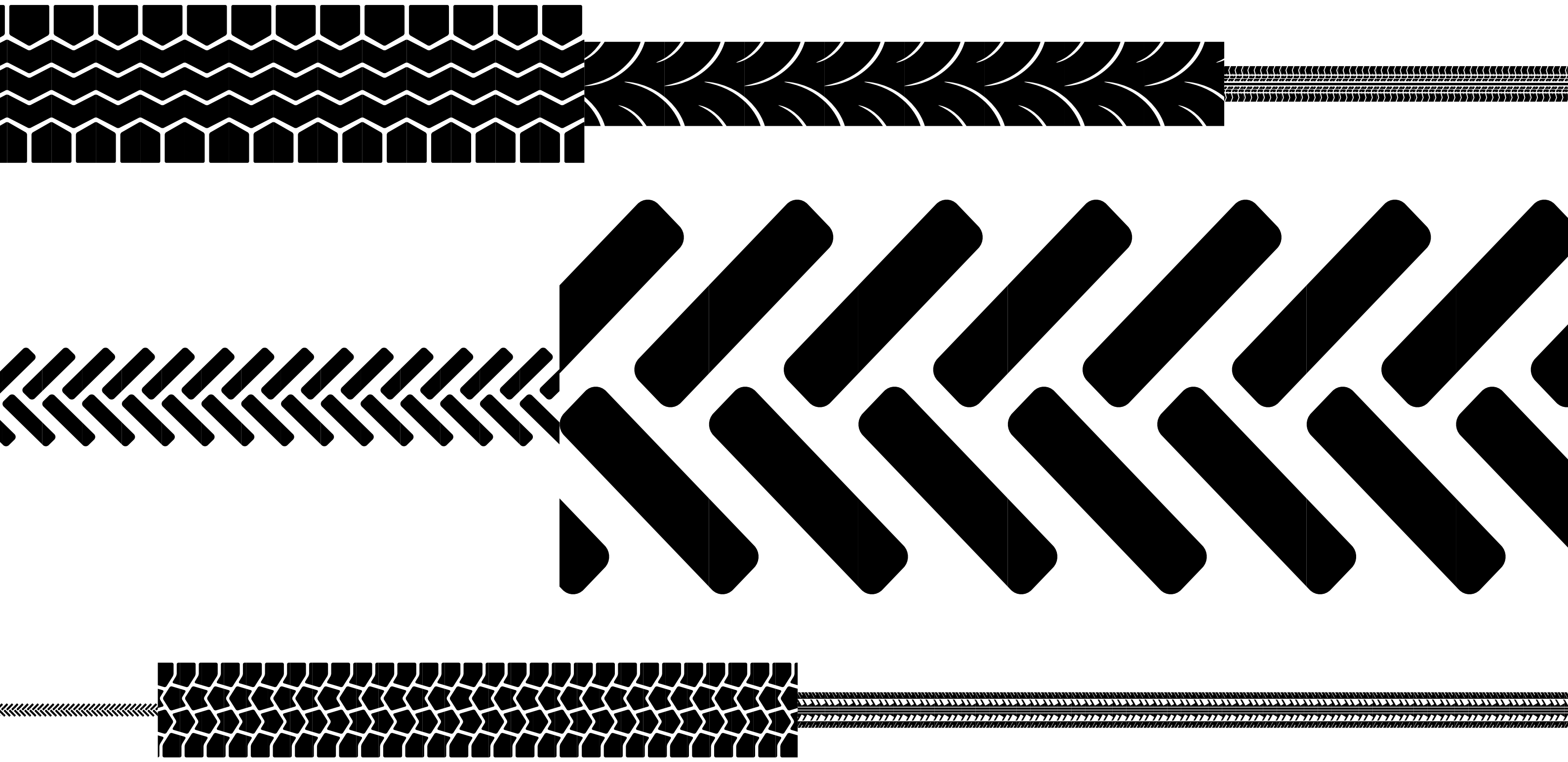
Auto Environmental Guide 2021

A comparative analysis of global automakers' decarbonisation: recent actions and future plans



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Authors

Lead authors

Ada Kong
Mingyang Zheng
Xixi Zhang

Contributing authors

Erin Choi
Madeleine Cobbing
Jiseok Kim
Daniel Read

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Valuable comments and input were provided by:

Hang Bao, Sarah Fayolle, Akiia Gong, Xidelong Guo, Arlo Hemphill, John Hocevar, Kelly Huang, Jude Lee, Yijing Li, Junyan Liu, Shuting Ren, Benjamin Smith, Federico Spadini, Benjamin Stephan, Marion Tiemann, Chengjian Xu

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Executive summary

The climate emergency is the most critical challenge of our times. In recent years, the unprecedented heatwaves and wildfires, heavy rains and floods, dying sea-life, melting polar ice and collapsing ecosystems provide painful reminders of just how far into the danger zone we have already plunged.

According to research by the Intergovernmental Panel on Climate Change (IPCC), unless there are immediate, rapid and large-scale reductions in greenhouse gas (GHG) emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach. There is a global consensus to address global warming and comply with the Paris Climate Agreement, and keeping global emissions within 1.5°C is an irreversible imperative.

This puts a big responsibility onto the industries responsible for the largest amounts of GHG emissions, and the passenger car industry is one of the most important of these. At a global scale, transportation is responsible for 24% of direct CO_2 emissions from fuel combustion, with passenger vehicles responsible for the largest chunk of these CO_2 emissions, at 45%.[1, 2] If no measures are taken to decarbonise the transportation sector, annual GHG emissions in 2050 will be 90% higher than they were in 2020.[3]

This report examines the commitments and actions of the ten biggest car manufacturers, representing 80% of the market, to evaluate whether they are taking effective steps towards decarbonisation. There are a few signs that this is starting, but so far, it's not nearly enough. This needs to speed up.

The key findings on the three central issues for car manufacturers to address are:

- **Earlier phase-out of the internal combustion engine is needed**

The current reality is that 99% of vehicles on the road are still burning fossil fuels, but the overriding need is for GHG emissions from road transport to be entirely decarbonised by 2050. The research identified that the phase-out of the internal combustion engine (ICE) should be brought forward. In leading markets this needs to be as early as 2030, and even sooner for markets such as Europe, by 2028.

Overall, none of the companies plan to phase out ICE vehicles earlier than 2035. Seven out of ten automobile groups, including Daimler, Ford, Nissan, Renault, Stellantis, Toyota, and Volkswagen, do not have a complete ICE phase-out date in any market for their main brands.

General Motors' aspiration sounds the most ambitious, with its claim to eliminate tailpipe emissions and sell only zero-emission light-duty vehicles (LDV) by 2035. Considering it currently sells just one electric vehicle model in the US, and its sales of battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) are still only 3.15% of its global vehicle sales, General Motors needs to take more action to show the world that these are more than just words.

Greenpeace values actions more than words. Therefore, in this evaluation, we put greater weight on the actual number of electric vehicles sold and their percentage of total vehicle sales between 2016 - 2020. Even though electric vehicles (EVs) appear to be an overwhelming trend in the market, when we look at the data for each company, this trend looks a lot less convincing. Toyota's sales of BEVs and FCEVs only account for 0.12% of global sales, with 2.16% for Hyundai-Kia, and 2.43% for Volkswagen. Although Honda aims to reach 100% EVs by 2040 globally, its 2020 BEV and FCEV sales are only 0.35% of its total sales.

When we look at the number of BEV/FCEVs sold, it's clear that none of these traditional car companies are fully committed or ready to take on the speedy transition out of fossil fuels that is needed. Many of the companies, such as Toyota and Stellantis, still plan to rely on plug-in hybrids as a means to reduce carbon emissions in their fleet, regardless of the fact that plug-in hybrid vehicle's real-life emission reduction level is far less than the official estimates.[4]

Carmakers should not only have more ambitious plans, with earlier dates for the complete phase-out of ICE vehicles, they also need to take much more aggressive action to make sure that the global market share of EVs sales will increase from today's single figures to 100% by as early as 2030.

- **The supply chain also needs to be decarbonised**

Electric vehicles are clearly a crucial part of the solution to cutting GHG emissions during use by passengers, especially if they are charged up with renewable energy. But the cars still have to be made, and there are high GHG emissions in the car manufacturing supply chain.

This is a problem that is not even properly quantified by carmakers, because of poor disclosure of their suppliers' GHG emissions data (Scope 3): half of the companies do not disclose this data, or only partially disclose it.

Many of these companies have carbon neutrality targets, but looking at the actual plans, eight out of ten of them are not specific enough, with carbon reduction plans that are not compatible with the 1.5°C target. These companies include Volkswagen, Toyota, Hyundai-Kia, and Stellantis.

- **Resource sustainability**

This transition from fossil fuels to electric vehicles will also need more batteries and electronics. These are resource intensive and rely on the mining and processing of minerals with high environmental and social impacts. Carmakers need to close the loop by reusing batteries and recovering the metals in them to use again. They also need to develop better battery technology that uses less resources. Without such developments, and if the market for electric passenger vehicles grows the way the industry would like it to, the projections show demand outstripping supply for some mineral resources by 2050.

Out of the ten companies, Nissan is the only one that has clear targets to reduce its use of raw materials and use secondary materials instead. None of the companies are investing enough in reusing and recycling capacity in comparison to what is needed.

Heavy lobbying activities against climate action

Under pressure from the growing global movement calling for climate action and the undeniable evidence of the climate emergency, policymakers are imposing ever tightening regulations. Automobile makers are reacting with strong lobbying efforts to fight against any restrictions. However, there is also increasing public attention on such lobbying efforts by the automotive industry. Toyota is among the most vocal industry players advocating for ICE vehicles, including hybrids, and even its investors have put pressure on the company to stop its negative anti-climate lobbying activities. The company has had to respond with a promise to review and be more transparent about its lobbying activities.[5]

What the automotive companies need to do:

1. These top car manufacturers should take social responsibility for acting on the climate emergency, at an ambition level that matches their advantage of scale and global market penetration. We demand that leading global automakers end the sale of ICE vehicles in main markets (US, China, Korea, Japan) before 2030. For the EU, this needs to happen by 2028. This is the key to achieving the low-carbon transformation of road transportation and to acting in time to prevent the worst effects of climate change. Meanwhile, such a transition should make sure that workers' voices are heard and their benefits are protected.

2. Transitioning to EV is not the end of the story. BEV is only green if we have more carbon free energy, therefore we need to drastically increase the supply of renewable energy. We also need to build the infrastructure to secure the capacity needed to reuse and recycle batteries. Automobile and battery companies' research and development should not only aim at improving battery performance, but more importantly, consider the full environmental impact of the battery's whole life cycle, with the goal of reducing resource consumption, carbon emissions and other environmental impacts, and improving the efficiency of repurposing and recycling.

3. Steel makes up the largest part of a car's carbon footprint at the manufacturing stage of a vehicle, contributing to half of cradle-to-gate emissions.[6] Steel is contributing to an increasingly large proportion of global carbon emissions, while decarbonising all steel production is not yet viable. Therefore we need to curb the growth of steel production and consumption by producing less unnecessarily heavy cars, such as SUVs, immediately, in order to save the climate. The SUVs marketing strategy promoted by the automobile manufacturers makes the problem worse. SUVs account for 42% of the global market share for cars in 2020. In general, the average SUV or pickup truck uses 20% more steel than the average car.[7] Car companies should reduce the production of them in order to curb the growth of steel consumption, while invest in fast-tracking the technological development of zero-carbon steel.

4. The expansion of electric vehicles over the last decade has been encouraged by a variety of support policies which were instituted in key markets. These helped to stimulate a major expansion of electric car models. However, we should beware the peril of a growing market for cars in the name of phasing out ICE vehicles. The phase-out of ICE vehicles must be accompanied by a reduction in the overall size of the fleet in order to achieve a meaningful climate impact. Ultimately, the true zero-carbon mobility future should involve far less private cars, more efficient public transport systems, more car sharing options, the redesign of cities to make space for walking and cycling, and less travel. Automakers will need to fundamentally rethink their business model, which at the moment is set on profiting from selling more cars at an ever faster pace, while governments need to devise better economic strategies to drive the world to a livable future.

Score table

	Overall grades	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
Toyota	F--	1.88	4.45		–
Stellantis	F--	2.88	3.05		–
Ford	F-	1.13	5.30		
Daimler	F-	3.13	2.30	+	–
Honda	F+	3.50	1.70	+	
Nissan	F+	3.31	5.40	+	–
Hyundai-Kia	F+	4.81	3.10		–
Renault	D-	4.31	6.75		–
Volkswagen	D	5.19	4.35		–
General Motors	C-	6.69	5.60		–

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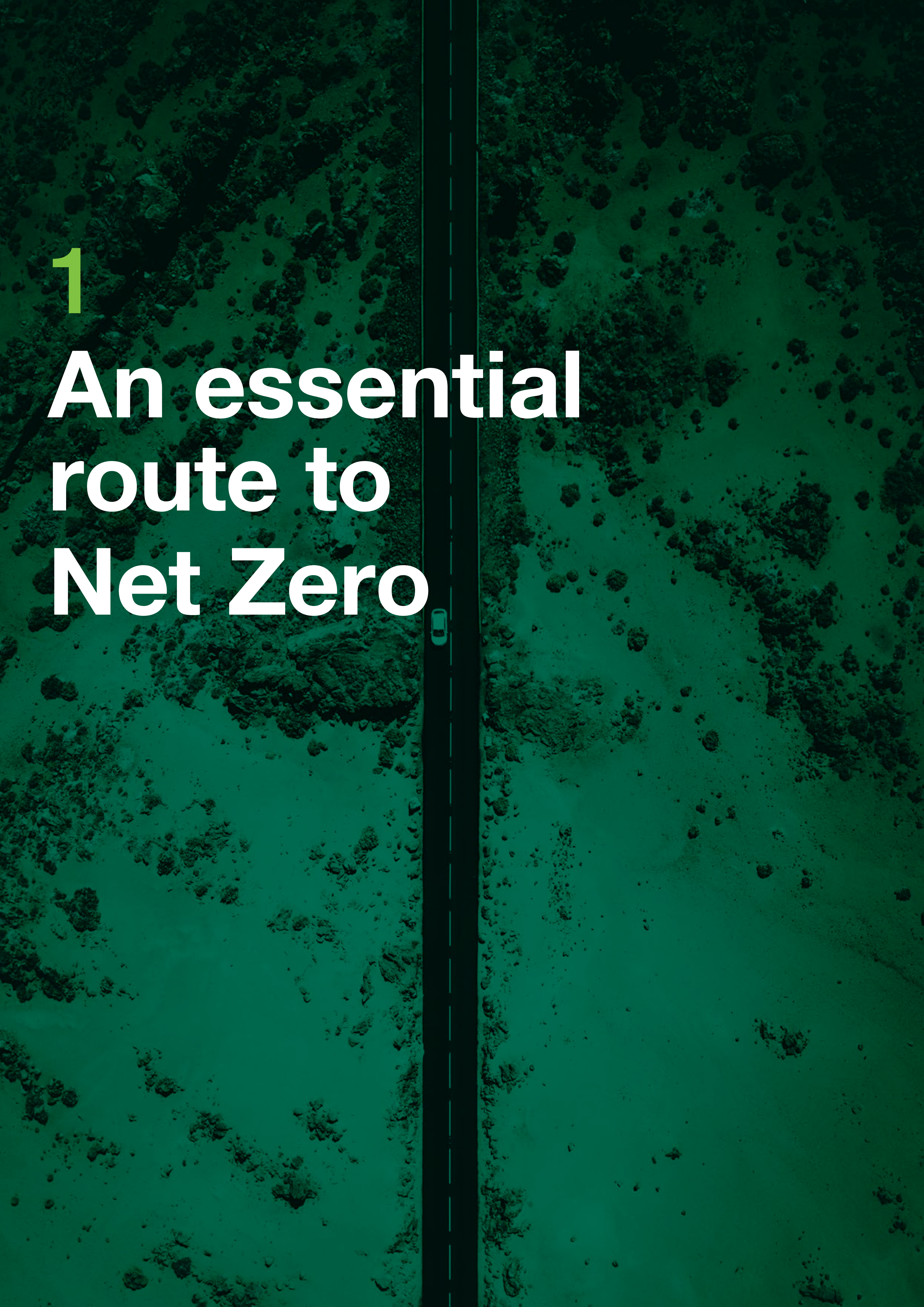

1 An essential route to Net Zero

1.1 Introduction

Since 1886, when the first internal combustion engine (ICE) vehicle was invented by Carl Benz, the automotive industry has undergone more than 130 years of development. In recent years, vehicles have played an increasingly important role in people's daily lives, with data showing that the global production of vehicles has risen from 58 millions in 2000 to 92 millions in 2019.[8]

The explosive growth of ICE vehicles has inevitably led to environmental and climate impacts. As of 2020, 99% of the total global fleet are ICE vehicles, powered by fossil fuels and releasing greenhouse gases (GHGs) and other pollutants such as methane, carbon monoxide, nitrogen oxides and hydrocarbons.[9]

The most recent report from the Intergovernmental Panel on Climate Change (IPCC) shows that emissions of GHGs from human activities are responsible for approximately 1.1°C of warming since the 19th century.[10] The unprecedented heatwaves and wildfires, heavy rains and floods, dying sea-life, melting polar ice and collapsing ecosystems provide painful reminders of just how far into the danger zone we have already plunged. According to IPCC's research, **unless there are immediate, rapid and large-scale reductions in GHG emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach.**

Many countries and regions have been aware of the problems caused by GHG emissions and taken measures, while the effects of these measures are not yet apparent. However, since the beginning of the 21st century, GHG emissions from the main sectors have not shown a downward trend, with emissions from most sectors remaining steady or increasing slightly in recent years. The two sectors that stand out as the highest emitters of GHG emissions – electricity/heat, followed by transportation – are also the sectors with the fastest growing GHG emissions (see Figure 1).[11] According to the International Council on Clean Transportation (ICCT), if no measures are taken to decarbonise the transportation sector, annual GHG emissions will be 21 billion metric tons by 2050, an increase of 90% from 2020.[3]

Figure 1.

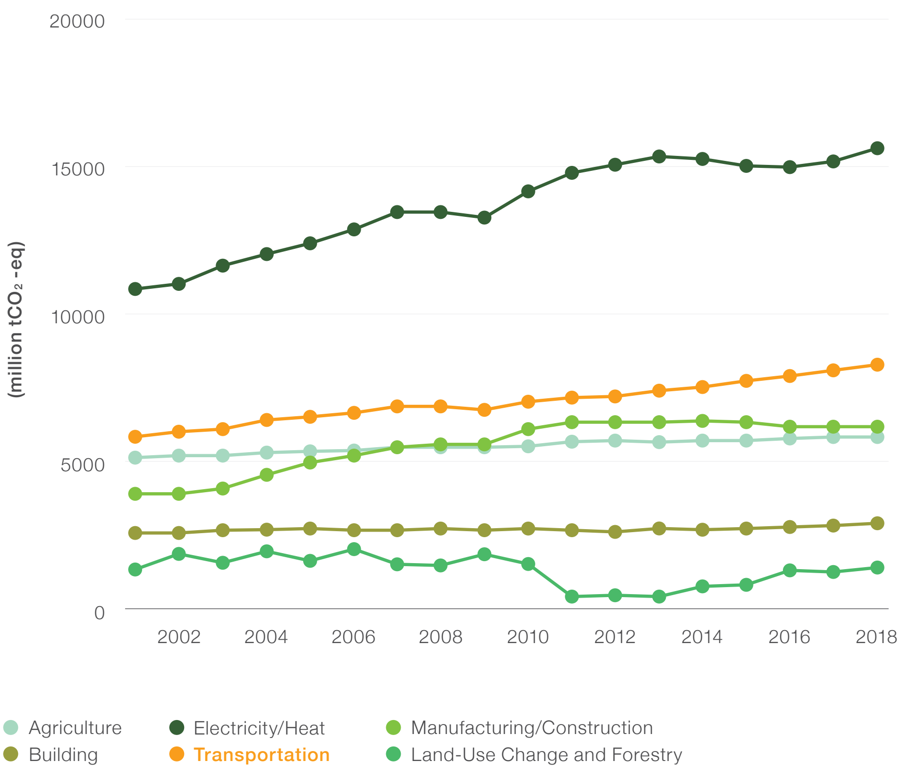

Figure 1.

Global GHG emissions by sector between 2001 and 2018 (Source: own compilation based on data from Our World in Data)[11]

In 2020, the CO_2 equivalent emissions from on-road vehicles were more than 9 Gt. Accounting for almost one-fifth of global CO_2 emissions, on-road vehicles have become one of the major CO_2 contributors. More than that, light duty vehicles – mostly passenger cars – release more CO_2 than any other form of transport, including heavy duty vehicles, and twice as much as the combined carbon emissions of aviation and shipping (see Figure 2).[3] Therefore, the transportation sector is in urgent need of low-carbon transformation, with the decarbonisation of passenger cars as the top priority.

Figure 2.

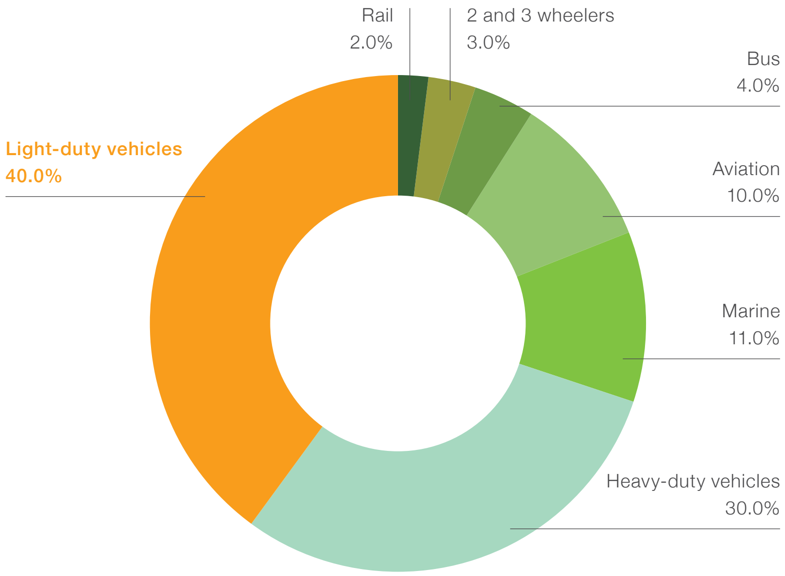

Figure 2.

Share of 2020 well-to-wheel CO_2 emissions from transportation, by mode (Source: own compilation based on data from ICCT)[3]

The key pillars

From the perspective of the life cycle of GHG emissions of an ICE vehicle, the majority of GHG emissions are released during its use, making up more than 80% of the life cycle emissions (see Figure 3).[12] Considering the large numbers of ICE vehicles currently on the road and still being manufactured, the decarbonisation of the use phase of cars is the most critical issue.

Figure 3.

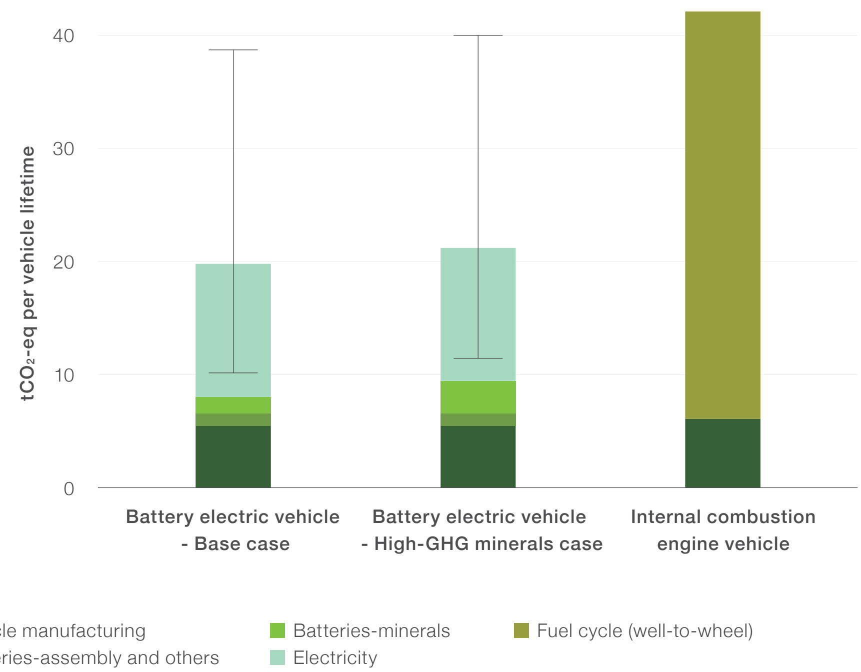

Figure 3.

Comparative life-cycle GHGs of a mid-size BEV and ICE vehicle (Source: International Energy Agency, IEA)[12]

Although the major automobile markets including China, the European Union (EU), Japan and the United States (US) have launched more and more stringent CO_2 emission standards for ICE vehicles, it's still not enough to reverse the growth trend of GHG emissions in the sector. Once tailpipe emissions drop to a certain level, it becomes very challenging and cost-intensive to reduce them further. Thus, phasing out ICE vehicles, accelerating the transformation to battery electric vehicles (BEVs) and increasing the provision of public transportation will be the fundamental solutions.

The importance of supply chain decarbonisation cannot be ignored. Accounting for about 20% of the life cycle GHG emissions, decarbonising the production phase of a car is harder than the use phase.[12] A passenger car needs about 20,000 – 30,000 components and parts, making the supply chain of the automobile industry long and complex.[13] Specifically, iron and steel are the most emission-intensive components for both ICE vehicles and BEVs, releasing around 1.7 tons of CO_2 for each vehicle.[14,15] As steel is widely used in many sectors, achieving carbon neutrality in the steel sector is of great significance to the world, which will also exert a profound impact on the automobile industry.

Additionally, the significance of resource sustainability in the automobile industry will increase over time. Apart from the demand for steel and aluminium, the promotion of electric vehicles has greatly increased demand for raw materials such as lithium, cobalt and nickel. Taking cobalt, which is used in cathodes in batteries, as an example, more than half of the world's cobalt was sourced from the Democratic Republic of Congo (DRC) in 2019, and DRC's cobalt reserves account for more than 70% of global reserves. In recent years, overexploitation and open-cast mines have caused grave threats to the health of local residents in DRC. More than that, mining has polluted land and water resources, and severe human rights abuses, including child labour, have been documented.[16] Therefore, carmakers need to make more urgent efforts to reduce the use of primary materials, promote the use of secondary materials and increase the level of resource recycling, in the process of electrification.

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1.2
ICE vehicles phase-out

1.2.1
The contribution of ICE vehicles to global warming

The transport sector is responsible for 24% of direct CO_2 emissions from fuel combustion, with light-duty vehicles making up nearly 45% of these CO_2 emissions.[1,2] From a life-cycle perspective, the tank-to-wheel emissions of ICE vehicles account for more than three quarters of their life-cycle CO_2 emissions, which are the main source of global road transport CO_2 emissions.[17]

Despite this, ICE vehicles still dominate the global automotive market. An average of more than 80 million ICE vehicles were sold each year between 2015 and 2020, accounting for over 90% of global passenger vehicles sales.[18] According to a Bloomberg forecast, global sales of ICE vehicles have reached their peak and will gradually decrease.[19] However, the rate of the reduction will be relatively slow at the very beginning, and ICE vehicles will make up a significant share of the global vehicles sales for a long time.


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1.2.2
The necessity of phasing out ICE vehicles

There is a global consensus to address global warming and comply with the Paris Climate Agreement. To achieve the goal, road transport CO_2 emissions will need to be entirely decarbonised by 2050. As the main way to achieve carbon neutrality, stopping the use of fossil-fuel powered cars has been widely recognized.

To date, more than 20 countries and over 40 cities around the world have introduced bans on ICE vehicles (primarily light-duty vehicles and buses) and pledged to speed up decarbonisation. For example, the UK has confirmed that the ban on new petrol and diesel cars has been moved forward to 2030, with some plug-in hybrid vehicles (PHEVs) and hybrid vehicles (HEVs) to be sold up until 2035.[20]

As the leading vehicle markets seek to reduce the impacts of emissions from transport on climate change, the phase-out of ICE vehicles has been in the international spotlight. Bans on ICE vehicles would effectively remove direct fossil fuel use from vehicles, decarbonising road transportation to a great extent. In addition, less ICE vehicles would substantially reduce direct tailpipe emissions and therefore improve the quality of the air we breathe and lower health risks from particulate pollution.

To align with the Paris Agreement targets of limiting global warming to below 1.5°C and to meet the carbon neutrality goal by 2050, the use of ICE vehicles must be halted as soon as possible. With this aim in mind, urgent actions such as phasing out new sales or registrations of ICE vehicles are needed.

1.2.3

The more carmakers gain, the greater the responsibility they should bear

Considering their market share and impact, the leading car manufacturers should take responsibility for decarbonising their products and further speed up the industry towards carbon neutrality.

In 2020, the ten best selling automakers made up about 80% of the global market. Moreover, Volkswagen AG (hereinafter Volkswagen for short) has stated that "1% of global CO_2 emissions are affected by our passenger car portfolio".[21] Therefore, **the efforts of auto manufacturers to end the use of ICE vehicles present an important long-term imperative to reduce CO_2 emissions. Their commitments are crucial market signals, which set in motion an urgently needed systemic transformation and make significant impacts on decarbonising the entire transport sector.**

While Greenpeace East Asia urges these market leaders to take the responsibility of leading the way, all transportation corporations need to join the collective endeavor to put the vehicle industry on a pathway to deliver GHG reductions in line with what is needed to meet the ambitions of the Paris Agreement.

1.2.4
Hybrid is not the solution

Although some carmakers have tried to reduce the GHG emissions of their products by producing HEVs, it should be noted that HEVs and PHEVs are not the real solution for the environment and the climate. Thus, **the electrification of transportation and the transition from ICE vehicles to BEVs should always exclude HEVs and PHEVs as they still rely on fossil fuel and have less potential for reducing emissions compared with pure electric vehicles.**

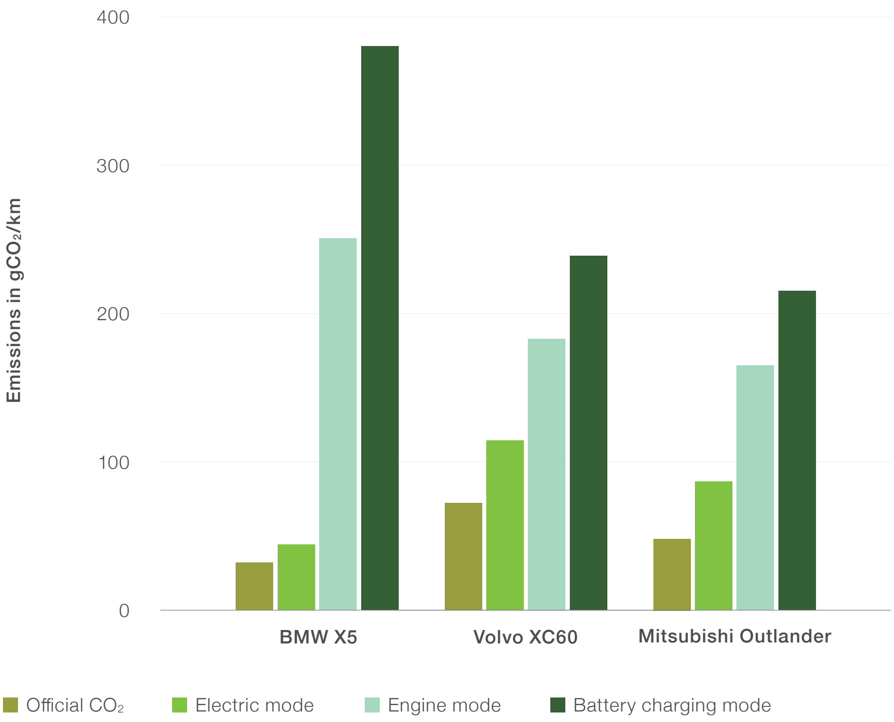
According to ICCT, the life-cycle GHG emissions of medium-sized BEVs are lower than comparable conventional ICE vehicles by 66% – 69% in Europe, 60% – 68% in the United States, and 37% – 45% in China. And when BEVs are powered exclusively by renewable energy, an 81% reduction is possible. However, the reduction of emissions from HEVs compared to ICE vehicles is estimated at only 20%.[18] The transformation from ICE vehicles to HEVs can only reduce GHG emissions from passenger vehicles to a very limited extent.

Even though some governments might give PHEVs an exemption from their ICE phase-out plans due to their allegedly low emissions, the actual advantage might be much lower than expected.[22,23] The real-world emissions of PHEVs can be far higher than the claimed values. A test conducted by Transport & Environment (T&E) sampled the emissions from a BMW X5, a Volvo XC60 and a Mitsubishi Outlander as examples, to evaluate the real-world emissions of the PHEVs. The results show that even running in full-battery mode, the tested vehicles pollute more than the claimed data. In engine mode and battery charging mode, the emissions can be 3 to 12 times higher than the official numbers (see Figure 4).[4]

Figure 4.

Official vs real-world emissions of plug-in hybrid vehicles (Source: Transport & Environment)[4]

Figure 4.

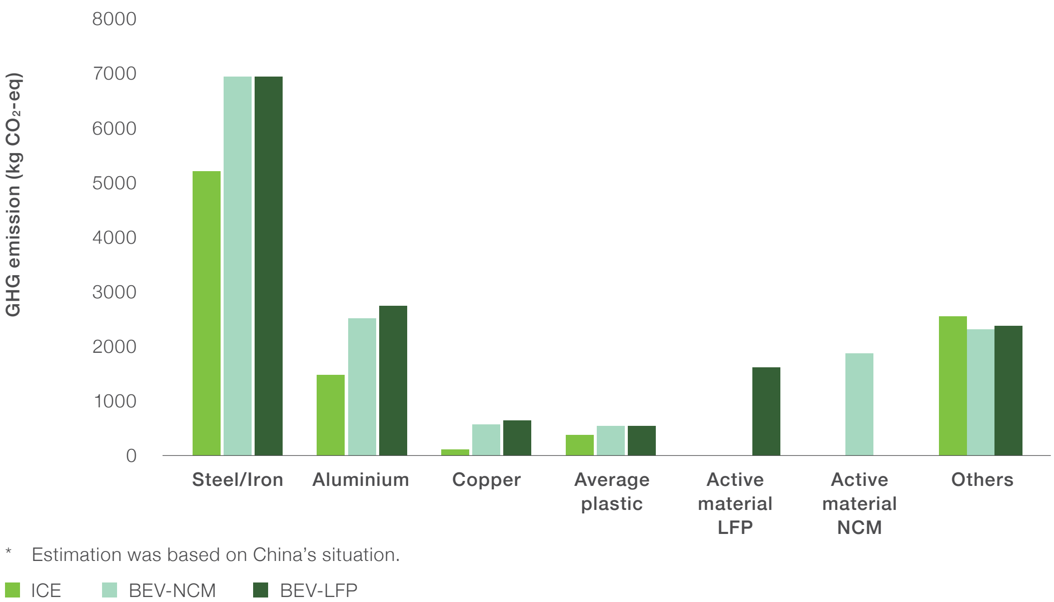


1.3 Decarbonising the supply chain

To remain within the 1.5°C warming target, reducing GHG emissions in the supply chain cannot be ignored. For ICE vehicles, the GHG emissions from vehicle manufacturing account for around 20% of a vehicle's life-cycle emissions, with mining and processing of steel and aluminium the main sources. Compared to ICE vehicles, the GHG emissions from manufacturing BEVs are even higher, accounting for 50% of life-cycle emissions.[12] The GHG-intensity of the BEV supply chain is mainly due to the batteries, followed by steel and aluminium (see Figure 5).

Given that the supply chain of the carmakers includes many industries and thousands of companies, decarbonising the supply chain is a systemic problem. Therefore, **implementing a comprehensive and holistic decarbonisation programme targeted at the upstream supply chain is urgent and necessary for the automobile industry's transition to electric.**

Figure 5.*



* Estimation was based on China's situation.

Figure 5.

Cradle-to-gate GHG emissions breakdown by materials (Source: Qiao, Q. et al.)[6]

1.3.1
Steel – A roadblock to supply chain decarbonisation

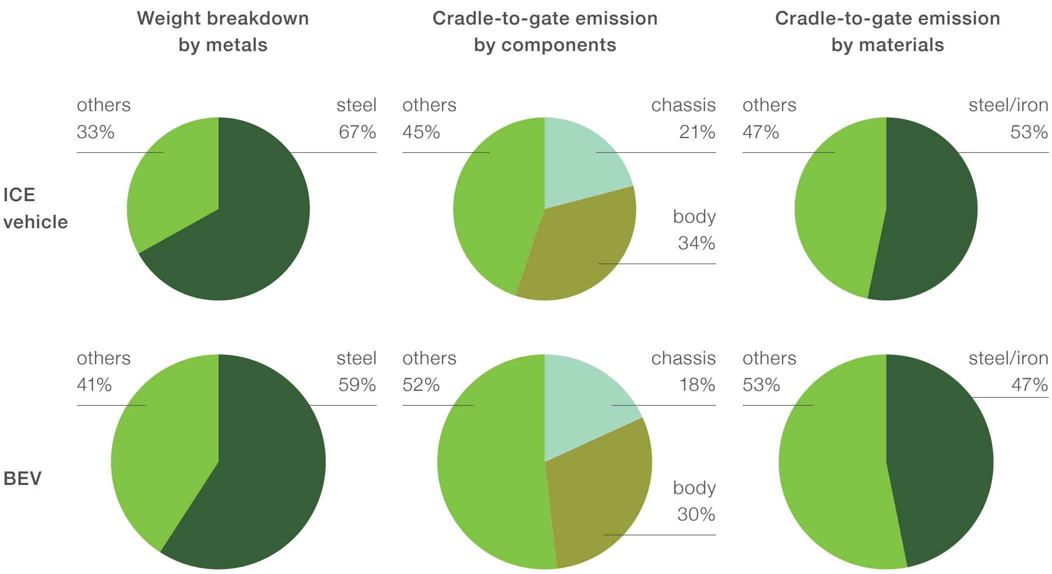
The heaviest components of a passenger car are the chassis and the body of the car, accounting for about half of the whole vehicle's weight, even the batteries of the BEVs are taken into account.[24]

The major material used to make the chassis is steel, which is also used in other parts such as closures, ICE vehicle's powertrains, etc. For BEVs, the use of other new materials leads to a lower proportion of steel to some extent, but steel is still the dominant metal (see Figure 6).

Figure 6.

The weight breakdown by metals and cradle-to-gate emission distribution of ICE vehicles and BEVs (Source: Qiao, Q. et al.)[6]

Figure 6.



GHGs released from the manufacturing of the car body and chassis are responsible for around half of the GHG emissions from the cradle-to-gate[i] production. Correspondingly, for materials, steel is also expected to be the major contributor to GHGs. The vast quantities of steel used make it the biggest contributor to a vehicle's emissions of GHGs in its manufacturing stage. GHG emissions from the production of iron and steel used for both ICE vehicles and BEVs make up 53% and 47% of the vehicle's manufacturing carbon footprint.[6]

With about 92 million vehicles produced in 2019, the carbon emissions from steelmaking for automotive production were about 150 million tons.[25] Therefore reducing the carbon footprint from steel is critical for the automotive industry, in particular for electric vehicle makers, to achieve carbon neutrality.

i Cradle-to-gate production, where raw materials like metals are extracted, car components are produced, and the whole vehicles are assembled (gate-to-gate).

1.3.2 Emissions from aluminium are climbing, in line with the trend for light weight design

After steel, aluminium is the second most common metal used in car production, and also the second largest contributor to GHGs among metals used in car manufacturing.

Aluminium is about one-third the weight of steel per cubic foot, enabling light-weighting. BEVs need to reduce their weight to offset the weight increase from the larger battery, thus the use of aluminium is rising. In 2019, the average aluminium content in cars of all types in Europe was 179.2 kg, and is estimated to increase by 19.6 kg in the next five years.[26] The larger battery needed for BEVs is a strong driver behind the rising aluminium content as it is used to make the battery box and body closures. BEVs use 45% more aluminium compared to ICE cars.[27]

Assuming an average content of 250 kg aluminium per vehicle, the 2018 aluminium demand for BEVs alone amounted to 250,000 tons, and it is forecasted to reach 10 million metric tons by 2030 (a tenfold increase on 2017).[28]

Aluminium production depends on the mining of bauxites and nepheline ore, on the refining of alumina, and on the smelting of primary aluminium, which is an energy-intensive process.[29] Aluminium production consumes around 5% of all electricity produced in the US, for example.[30] The 2018 global average cradle-to-gate emission intensity of aluminium is as high as 17 tCO_2-eq/t, with over half of this in the form of electricity.[31] This also offers a quick opportunity to decrease GHG emissions – by adopting renewable energy. When shifting from coal-fired electricity to low carbon power, the emission factor for aluminium could drop to 5 tCO_2-eq/t.[32]

1.3.3 Batteries, a growing concern in the supply chain

With the age of electrification upon us, battery prices have dropped dramatically by more than 97% since they first entered the market in the 1990s.[32] However, there has been no corresponding reduction in their manufacturing carbon footprint.

The production of a battery involves a variety of energy and resource intensive activities – from the off-site raw material mining and refining, to the battery grade material production, and finally the cell assembly. It is estimated that about 18-50, 60-70 and 70-110 kg CO_2-eq are emitted respectively for each of these three steps, for the production of every kWh battery.[33] The GHG emissions for producing the whole battery pack are estimated to be about 163 kg CO_2-eq/kWh.[34]

For a 1 kWh energy content cell, the cathode paste is the second largest contributor, accounting for 28% of GHG emissions.

Compared to other metals, the production of the metals used to make the cathode have a higher emission intensity. 2.7-5 kg CO_2 is emitted from 1 kg of copper and 1.7 kg CO_2 from 1 kg of steel, but the highest emission factors are for cobalt – reaching 9-10 kg CO_2-eq/kg, and nickel – with 5.25-10 kg CO_2-eq/kg.[35]

1.4
Resource sustainability

The massive transition from ICE vehicles to electric vehicles (EVs) requires disruptive changes to the supply chain of vehicle components and materials, such as the use of aluminium and carbon fibre instead of steel for lightweight design. New supply chains are also required for EVs, including power electronics, electric motors, and batteries. Concerns about the sustainability of the material supply chain for EVs, and related environmental impacts have been voiced, especially for EV batteries.

1.4.1
The growing demands and supply risks

Considering the future development of the EV fleet and the realities of battery chemistry, the demand for battery materials for use in passenger cars will increase sharply.[36] Figure 7 shows the demand for lithium, cobalt, and nickel for every five years between 2020 and 2050, respectively, and the related increases when EV stock reaches 25% of the market by 2050, in one scenario, with NCM and NCA[ii] batteries dominating the future battery market.

The figure shows that lithium demand could increase from 0.04 million metric tons to 0.64 million metric tons in 2050, 18 times of the demand in 2020; cobalt from 0.04 million metric tons in 2020 to 0.61 million metric tons in 2050, 17 times of the demand in 2020, and nickel from 0.14 million metric tons in 2020 to 3.74 million metric tons in 2050, 28 times of the demand in 2020.

Figure 7.

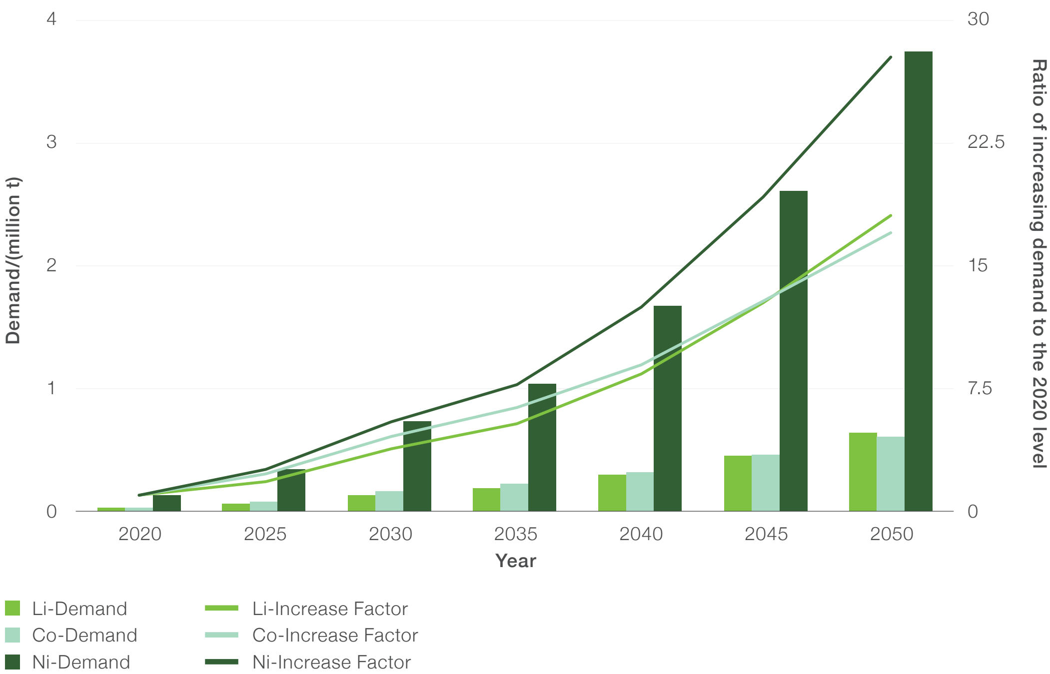


Figure 7.

Lithium, cobalt, and nickel demand (left) and the ratio of increasing demand in 2020-2050 to the 2020 level (right) for EV batteries under the stated policy scenario (EV stock reaches 25% market share) and NCA and NCM batteries dominate the chemistry scenario (over 90% share of the future battery market. Li for lithium, Co for cobalt, and Ni for nickel). (Source: own compilation based on data from Xu, C. et al.) [37]

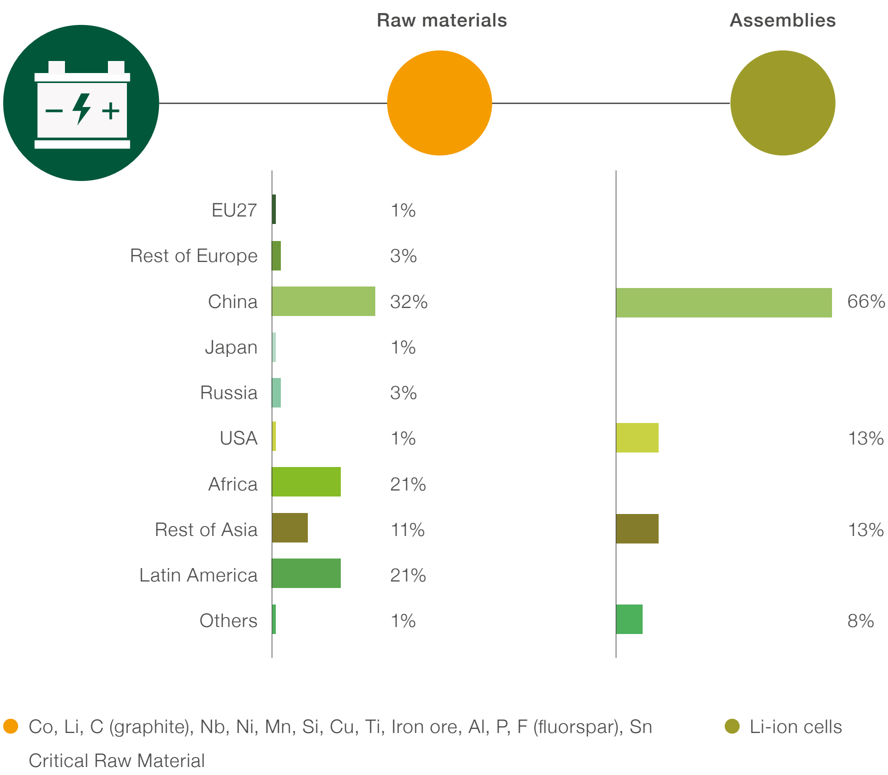
ii Depending on cathode chemistry, the materials normally used by current EV manufacturers are lithium, nickel, cobalt, manganese oxide (for NCM batteries), lithium, nickel, cobalt, aluminium oxide (for NCA batteries).

The availability of raw materials is key to building the battery supply chain. Countries and regions such as China, the EU and the US are concerned about the availability of the raw materials, and have set up strategic plans to secure the supply of raw materials for the battery industry. For example, lithium, nickel, and cobalt are identified as critical materials by the EU for their high economic importance and potential supply shortages (see Figure 8).[38]

Figure 8.

Overview of supply risks, bottlenecks and key players along the supply chain of EV batteries (Source: European Commission)[39]

Figure 8.



1.4.2 Alternative scenarios for future battery technology

It's also necessary to take a broader look, and consider other scenarios where NCM and NCA batteries may not be the dominant technology by 2050. Although they are likely to form a part of the battery mix going forward, there is also a lot of development ongoing on other types of batteries.[39] These include LFP (lithium iron based – the main battery type currently used in the market in China) and nickel-manganese (but not cobalt) based batteries that entered the market in 2020. But there could also be other battery technologies in the future, such as lithium-sulfur, lithium-air (oxygen), and solid state lithium. These technologies are less developed but have the potential to enter use before 2050, which raises the possibility of even more dramatic changes in the types and amounts of individual metals that will be needed, especially in relation to moving away from nickel and cobalt entirely.

iii The deep sea usually refers to areas covered with >200m depth of seawater.

Box 1:
Deep sea mining and the EV batteries boom

The deep sea[iii] covers around 65% of the planet's surface.[40] The remote deep and open oceans host a major part of the world's biodiversity, and are vital for our survival on Earth. The deep sea plays an important role in regulating planetary processes, including regulation of temperature and greenhouse gases. It supports ocean life by cycling nutrients and providing habitats for a staggering array of species.[41]

The urgent need to move away from fossil fuels and transition to a low-carbon economy will fuel demand for certain types of minerals. The search for new sources of mineral supplies is turning to the sea floor.

Private deep-sea mineral extraction companies are pitching themselves to electric vehicle and battery companies as a "greener, more socially just" alternative to land-based mining. But the practice of deep sea mining (DSM) would destroy ocean wildlife in its path and disrupt ocean biodiversity by spewing waste into the water column and onto the ocean floor, potentially releasing deep carbon stores that could increase climate change, and disrupt deep-sea ecosystems and food chains.

Impacts of deep seabed mining

Oceans are critical to sustainable development and contribute to poverty eradication by providing sustainable livelihoods and food security for billions of people around the world. They are also the primary regulator of the global climate and huge reservoirs of biodiversity.[42] With planetary boundaries increasingly exceeded as a result of human activities,[43] the development of commercial DSM activities poses a major threat to our oceans, which are already suffering from a number of pressures including the effects of climate change, overfishing, acidification or pollution, to name a few. Allowing commercial scale mining operations to proceed means opening a whole new frontier of industrial extraction in one of the largest biomes of the planet.

All types of seabed mining will kill whatever cannot escape the mineral extraction operations. Organisms that grow on the seabed will be smothered as a result of sediment disturbance and the discharge of waste. The current lack of scientific knowledge on the deep-sea environment, and the lack of knowledge of the technology employed, limits our ability to predict the environmental impacts of mining operations and to determine whether habitats can ever recover from the disturbance.[42,44,iv] The Greenpeace Science Unit has done some extensive reviews of available literature on the potential impacts of DSM which include physical destruction of seabed habitats, creation of large underwater plumes of sediment and the effects of chemical, noise and light pollution arising from mining operations.[45]

Corporate actions so far

Companies like BMW, Volvo, Samsung and Google, which have major demands for battery raw materials, have already pledged not to use metals and minerals from deep-sea mining activities unless and until the environmental risks are comprehensively understood.

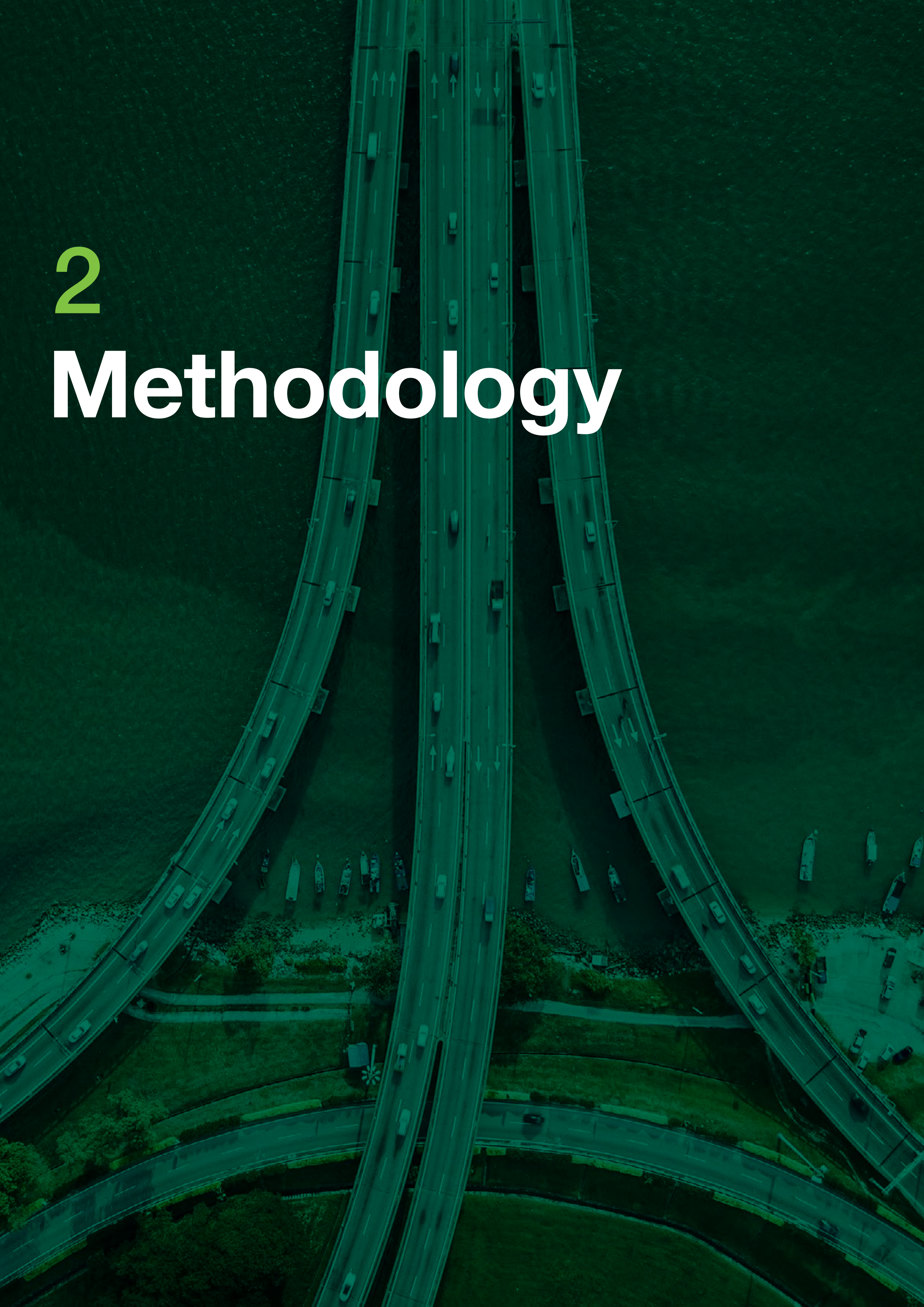
In addition, industry experts are calling for mandatory recycling of minerals and metals, like the ones seabed miners are targeting, to ensure the transition to the clean energy economy is actually clean and green.

Seabed mining would be a risk to the ocean on multiple fronts. We know the ocean is under a multitude of pressures, and that scientists are warning us in report after report that it's in dire straits. Destructive fishing practices, pollution and climate change are pushing the ocean to the brink, and we desperately need to take the pressure off, not add a new one into the mix.

Globally, Greenpeace is calling for deep sea mining to be banned. In order to increase the resiliency of marine ecosystems, Greenpeace is advocating for the creation of a global network of sanctuaries, fully protected from extractive industry.

iv A paper just published, for instance, shows how the effects of simulated mining impacts induced during an experiment conducted in 1989, were still evident 26 years later. (See "Biological effects 26 years after simulated deep-sea mining")

2 Methodology



To evaluate companies in the report, we used publicly available information from each company, including corporate communications, CSR reports, public submissions to stakeholders and reporting bodies as well as media coverage. In addition, information from third-party databases like Bloomberg terminal and Marklines were also used as references.

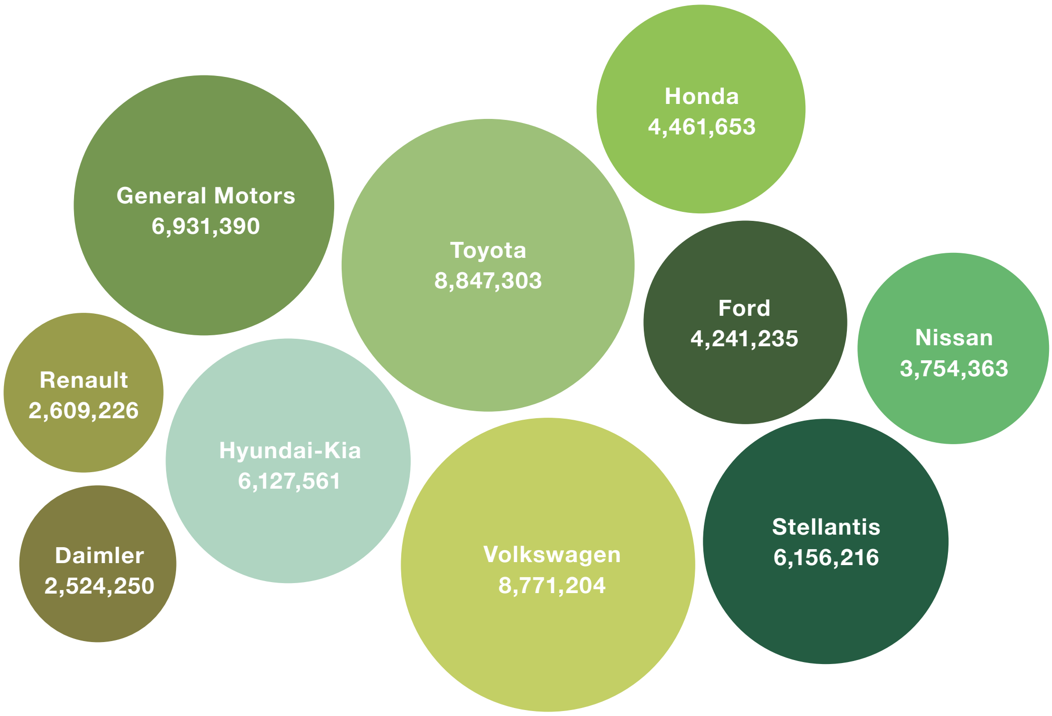
The manufacturers

Based on the sales of the companies in 2020, the performance of the top ten carmakers in the world have been evaluated in this report. The companies and their vehicles sold in 2020 were listed (see Figure 9). In order to be consistent in the evaluation, available data on sales from Marklines was used. These data were retrieved on 13 September, 2021. Unless otherwise specified, all sales data in this report come from Marklines. It is worth noting that the data from Marklines can be lower than sales data provided by the companies. Sales data for the companies in joint ventures have only been included when this accounts for more than 50% of the joint venture, except for China.[v]

Figure 9.

Companies and number of vehicles sold in 2020 (Source: own compilation based on data from Marklines)

Figure 9.



v Under Chinese law, the previous restriction of limiting foreign enterprises ownership in joint ventures to 50% has in recent years gradually been lifted.

The guidelines

Companies were then ranked according to:
1. Their performance on **phase-out of ICE vehicles** and
2. Their performance on **supply chain decarbonisation**.

The contribution of tank-to-wheel GHG emissions during the life cycle of a car could be as high as 80%, therefore, scores for companies' performance on phasing out ICE vehicles are allocated 80% of the points. The remaining 20% goes to performance on decarbonising the supply chain.[12,18]

In the score table, the scores range from 0-10, from the worst to the best. The two sections "performance on **phasing out ICE vehicles**" and "**decarbonising the supply chain**" are scored first and transformed to a 10-point scale in the score table. The overall score for each company is made up by combining the two sessions. Then the overall score is transformed to the overall rating using the grading system on the right.

Grading system		
8.5 ≤	A	< 10
7 ≤	B	< 8.5
6.5 ≤	C+	< 7
6 ≤	C	< 6.5
5.5 ≤	C-	< 6
5 ≤	D+	< 5.5
4.5 ≤	D	< 5
4 ≤	D-	< 4.5
3.5 ≤	F+	< 4
3 ≤	F	< 3.5
0 ≤	F-	< 3

Performance on phasing out ICE vehicles: 80% of total score

Performance in 2020 (30%)

For this criterion, the car companies are ranked according to:
1. The volume of sales of BEVs and FCEVs (15%)
2. The percentage of BEVs and FCEVs in relation to the total units sold (15%)

The larger the volume of BEV and FCEV sales, the higher the score will be. The same is true for the percentage of units sold. Note that we set a threshold to evaluate the percentage of BEVs and FCEVs sold, according to the percentage of BEVs and FCEVs of global car sales in 2020 which was 3.08%. That means that companies with sales of BEVs and FCEVs at a lower percentage than this, will be scored lower than 6 for this criterion.

Performance during the past five years (30%)

For a more comprehensive assessment, the compound annual growth rate (CAGR) of BEVs and FCEVs proportion and the cumulative sales of BEVs and FCEVs between 2016 and 2020 are employed as the indicators to evaluate the companies' performance on the phase-out of ICE vehicles. The CAGR of BEVs and FCEVs accounts for 10% of the overall score and the cumulative sales of BEVs and FCEVs over the past five years account for 20% of the overall score. The larger the cumulative sales numbers are, the higher the score will be. The same is true for the CAGR. We have also set a threshold for the CAGR of BEVs and FCEVs proportion, at 56%, referring to the global data. The compound annual growth rates are calculated as follows:

$$\mathrm{CAGR} = \left(\frac{V_{\mathrm{final}}}{V_{\mathrm{begin}}}\right)^{1/t} - 1$$

CAGR = compound annual growth rate
V_{begin} = beginning value
V_{final} = final value
t = time in years

ICE phase-out plan (20%)

For this criterion, the publicly announced targets of the companies to phase out ICE vehicles are evaluated. A commitment is ranked based on the target year for the ICE vehicles phase-out plan. Only commitments published on the company's own official channels are assessed. Targets that specify plans for BEVs and FCEVs are assessed, but the targets including PHEV and HEV plans are excluded.

Performance on decarbonising the supply chain: 20% of total score

The GHG Protocol defines emissions of GHGs as Scope 1, 2 and 3, which are the basis for GHG reporting. Scope 1 and 2 are mandatory to report, whereas Scope 3 is voluntary and the hardest to monitor:

Scope 1: Direct emissions occur from sources owned or controlled by the company

Scope 2: Indirect emissions from the generation of purchased energy

Scope 3: Indirect emissions that are a result of an organization's operations, but are not owned or controlled by the company

Scope 1 and 2 are GHG emissions from the business activities of the companies, the former being direct emissions from the use of fossil fuels and the latter being indirect emissions from the use of purchased energy resulting from generation of electricity by power plants and other facilities. Scope 3 emissions are indirect emissions associated with each product from the purchase of raw materials to end use by customers and disposal.

In this evaluation, the GHG intensity of Scope 1 and 2 are considered, while for Scope 3, only the GHG emissions from purchased goods and services are employed as the indicator. This category includes all upstream (i.e., cradle-to-gate) emissions from the production of products purchased or acquired by the company in the reporting year.[vi]

Scope 1 & Scope 2 GHG intensity in 2020 (7%)

In this criterion, the supply chain decarbonisation performance of the companies is evaluated according to the GHG emissions that result from the production of the cars. Their performance on decarbonising the company's operation and their manufacturing process in 2020 is calculated by the formula below. The company is ranked according to GHG emissions of Scope 1 and Scope 2 per sales of cars in 2020.[vii] The lower the GHG emissions are, the higher the score will be. It's worth mentioning that either location-based[viii] GHG emissions or market-based[ix] GHG emissions that the companies disclose in scope 2 is accepted in this report.

Intensity = GHG emissions of Scope 1 + GHG emissions of Scope 2/sales number in 2020

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vi According to the data sources, Daimler, FCA, Nissan and Toyota only disclose CO_2 emissions, while the rest of the companies disclose GHG emissions. In this report, the difference between CO_2 emissions and GHG emissions is neglected as CO_2 emissions account for the vast majority of GHG emissions for the automobile companies. However, the global warming potentials of other GHGs are even higher. Thus, a comprehensive disclosure of GHG emissions is essential and the incomplete disclosure of the companies will be taken into consideration in future evaluations.

vii The report uses Toyota's 2019 GHG emissions data as the data in 2020 has not yet been released.

viii The location-based method reveals what the company is physically putting into the air.

ix The market-based method shows emissions the company is responsible for through its purchasing decisions.

Disclosure and upstream supplier GHG intensity in Scope 3 (7%)

Apart from the GHG intensity of Scope 1 and Scope 2, the disclosure and decarbonisation performance on the purchased goods and services of Scope 3 are also evaluated in the report. Companies that only partially disclose their GHG emissions in this category will automatically get lower than 6 points for this criterion, and those that comprehensively disclose this information are ranked according to GHG emissions per sale of cars in 2020.[x] The lower the GHG emissions are, the higher the score will be. The GHG intensity is calculated using the formula below:

Intensity = GHG emissions of purchased goods/sales number in 2020

Carbon reduction plan (6%)

Carbon reduction plans mainly evaluate the publicly announced targets of the companies on carbon neutrality. The data is extracted from Science Based Target initiatives (SBTi).[xi] For this criterion, both the GHG reduction level and the year of carbon neutrality are taken into account. The minimum requirements for a company to get 6 points of score are:

1. The carbon neutrality year of the company should not be later than 2050, and;
2. The GHG emissions from company operations (Scope 1 and Scope 2) should be consistent with the reductions required to keep warming to well below 1.5°C, as recognized by SBTi. This requirement is consistent with the pathway recommended by IPCC to limit warming to 1.5°C.

If subsidiaries commit to the targets, the score will depend on the level of the commitment and the business contribution of the subsidiaries to the group.

Resource sustainability

Apart from performance on phasing out ICE vehicles and supply chain decarbonisation, resource sustainability is also evaluated in this ranking report.

Considering the intensity of GHG emissions from the extraction of raw materials used in the automobile industry and the huge number of end-of-life (EoL) EV batteries that can be expected in the near future, this report also highlights the companies' performance on resource sustainability including raw material reduction, secondary material usage and EV battery recycling and reuse. Effective practices in resource sustainability will not only reduce the environmental pollution caused by raw material acquisition, but will contribute to the stable supply of resources in the future.

There are three criteria under this pillar. The first is to have ambitious and holistic targets on raw materials reduction. The second is to have ambitious and holistic secondary material usage targets which contribute to the increasing demand for secondary materials. It is worth noting that the primary concern is metals, due to high carbon footprint and environmental impacts. Therefore, holistic raw materials reduction and secondary materials usage must include targets on metals. The third criterion looks at whether the company invests in building capacity for EV battery reuse and recycling. A quantifiable and significant recycling and reuse capacity with a clear time plan will be included, regardless of whether the facility is self-constructed or co-constructed with partners. Among the ten companies, the one(s) that contributed highest battery recycling and battery reuse capacity will be credited.

A performance for resource sustainability which satisfies these criteria will increase the overall score by half a grade, which is presented as a "+" in the score table.

x The report uses General Motor's 2019 scope 3 GHG emissions data as the data in 2020 has not yet been released.

xi The SBTi is a partnership between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF). From the perspective of the third party, SBTi mobilizes the private sectors to take urgent climate action by providing guidance on the companies to set a pathway to reduce GHG emissions in line with the Paris Agreement target limiting global warming to 1.5°C.

Deductions

Half a grade is deducted from the overall score for any examples of negative climate lobbying or serious violation of emission regulations, since 2019. This includes earlier instances that have become legally actionable post-2019. The deduction is presented as a "–" in the score table.

Detailed information on the scores of each company are presented in the company profiles in the Appendix.

Considering mergers and acquisitions, it is necessary to explain the scoring process of the following companies.

Stellantis

As PSA and FCA were merged into Stellantis early in 2021, the information about their performance in 2020 was collected separately for the evaluation. The scores of the two companies are presented separately in the company profile. In the overall rating, the performance of these two companies is integrated as a whole and presented as Stellantis Group. Specifically, in the section on phasing out ICE vehicles, the BEV sales of the two companies were put together and the proportions and CAGR were calculated using the combined sales. Regarding the supply chain decarbonisation section, the disclosed GHG emissions of Scope 1 and Scope 2 of FCA and PSA are combined to calculate the GHG intensity, while PSA doesn't disclose the GHG emissions from upstream suppliers in Scope 3 in 2020, the performance of the group on this item is considered as partially disclosed information and the score is 3.

Hyundai-Kia

In this report, Hyundai and Kia is evaluated as a whole, as they share technologies, vehicle platforms, and development strategies to a great extent. But their global ICE phase-out and carbon reduction plans were presented and evaluated separately, given their different commitments. As with Stellantis, in the supply chain decarbonisation section, the disclosed GHG emissions of Scope 1 and Scope 2 of Hyundai and Kia are combined to calculate the GHG intensity; because Kia doesn't disclose the GHG emissions from upstream suppliers in Scope 3 for 2020, the performance of the group on this item is considered as partially disclosed information and the score is 3.

Nissan & Renault

Although Renault Group, Nissan Motor Co., Ltd. and Mitsubishi Motors Corporation formed an alliance in 1999, the strategic partnership between the three companies is not a merger or an acquisition. The decision-making of these companies is also independent. In this case, this report considers Nissan and Renault as independent car manufacturers.

3
Evaluation

3.1 ICE phase-out

As many countries and regions have introduced stringent emissions regulations or market access standards, automotive manufacturers have come under pressure to manage emissions. Thus, some companies have formulated plans to deal with stricter laws and rules. But none of these plans is progressive enough to match the ambition of the Paris Agreement.

3.1.1 No ICE phase-out date earlier than 2035

In general, General Motors scores relatively higher in this pillar, with Ford and Toyota left far behind.

In the process of transitioning towards BEV/FCEVs, General Motors "aspires" to the earliest target for termination of global ICE sales. In early 2021, the company stated that it plans to sell exclusively zero-emission models[xii] globally by 2035.[46] However, later in the year, General Motors, Ford and Stellantis jointly announced that they aim to achieve sales of merely 40-50% of annual US volumes of electric vehicles, which includes plug-in hybrid vehicles, by 2030.[47] This announcement is seemingly not living up to the General Motors' aspiration to be fully electric by 2035. Furthermore, considering it currently sells just one electric vehicle model in the US, and BEV/FCEVs only account for 3.15% of its global vehicle sales, General Motors needs to take more action to show the world that these are not just words. Honda is another company that announced a global ICE phase-out date which is 2040.[48] Hyundai-Kia aims to phase out all vehicles using fossil fuels in major markets such as the United States, Europe, South Korea, and China by 2040 while maintaining ICE vehicle production capacity in emerging markets including India, Russia and Brazil.[49]

Overall, seven out of ten automobile groups, including Daimler, Ford, Nissan, Renault, Stellantis, Toyota, Volkswagen, do not have a complete ICE phase-out date in any market for their main brands.

It is worth mentioning that several manufacturers tend to have different plans in different markets. For example, Nissan has a target that more than 40% of its US vehicle sales by 2030 will be fully electric,[50] and for other markets, such as Japan, China, and Europe, all-new vehicle offerings will be electrified by 2030.[51] Ford has promised that its models will be fully electric by 2030, but only in Europe.[52] Similarly, Volkswagen has also formulated more radical transformation plans for the European market compared to those for the rest of the world.[53] Honda committed that BEV/FCEVs will account for 40% of global sales by 2030. Yet, this will only be 20% in the Japanese market.[48]

xii According to the definition made by General Motors, all vehicles produced then will be entirely powered by electricity.

3.1.2
BEV/FCEVs are still a tiny fraction of sales

Global vehicle sales in 2020 were 68.18 million units, but this includes only around 2.1 million units of BEVs and 0.01 million units of FCEVs. Although the global stock of electric cars hit the 10 million mark this year, 99% of the total global fleet is still burning fossil fuels.[54] For the majority of countries, the percentage of EV sales was still below 10% in 2020, with some markets such as the US or Japan barely making it to 2% or 1%.[55] Given that vehicle usage accounts for around 80% of the life cycle GHGs for ICE cars, the critical issue is the tailpipe emissions from the number of vehicles on the road.

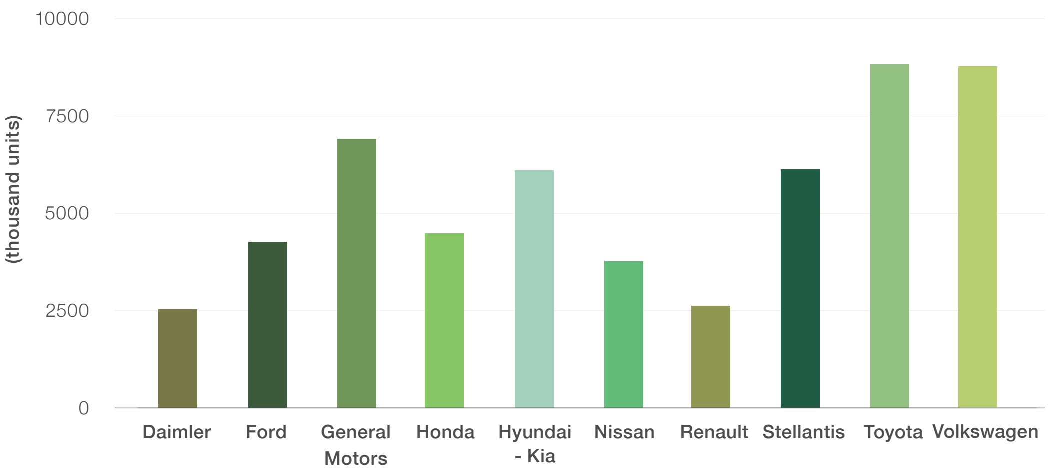
3.1.3
Battles for phasing out ICE vehicles between competitors

It is relevant to make some comparisons between companies with similar sales numbers for 2020, namely Toyota and Volkswagen, Daimler and Renault (see Figure 10), to compare their performance.

Figure 10.

Global sales of all vehicles by company in 2020 (Source: own compilation based on data from Marklines)[56]

Figure 10.



Volkswagen vs Toyota

Despite a similar volume of sales in 2020, the performance of Volkswagen and Toyota varies considerably in terms of phasing out ICE vehicles (see Table 1). Volkswagen's global BEV sales in 2020 were 23 times higher than Toyota's. Even though Toyota sold 1,564 FCEVs in 2020, Volkswagen has a higher percentage of BEV/FCEVs than Toyota. Over the past five years, Volkswagen's cumulative sales of BEV/FCEVs are 20 times higher than Toyota's. And obviously, Volkswagen's compound annual growth rate for BEV/FCEV proportion is much higher.

Table 1. Comparison between Volkswagen and Toyota

	Volkswagen	Toyota
Global sales of all vehicles in 2020	8,771,204	8,847,303
BEVs sold in 2020	212,959	9,154
FCEVs sold in 2020	0	1,564
BEV/FCEVs sold in 2020 as a percentage of global sales	2.43%	0.12%
Cumulative sales of BEV/FCEVs between 2016 and 2020	212,959	10,718
Compound annual growth rate of BEV/FCEV proportion between 2016 and 2020	108.45%	54.74%

Daimler vs Renault

Daimler and Renault had similar volume of global sales in 2020. However, the latter sold more cars without ICE (see Table 2). Renault performs better than Daimler in eliminating ICE vehicles. Renault sold far more BEVs than Daimler in 2020. In terms of sales of BEV/FCEVs as a percentage of all vehicles sold in 2020, Renault performs better. Renault's cumulative sales of BEV/FCEVs between 2016 and 2020 were twice as high as Daimler's. And Renualt also had a higher compound annual growth rate of BEV/FCEV proportion between 2016 and 2020.

Table 2. Comparison between Daimler and Renault

	Daimler	Renault
Global sales of all vehicles in 2020	2,524,250	2,609,226
BEVs sold in 2020	46,978	114,008
FCEVs sold in 2020	0	0
BEV/FCEVs sold in 2020 as a percentage of global sales	1.86%	4.37%
Cumulative sales of BEV/FCEVs between 2016 and 2020	46,978	114,008
Compound annual growth rate of BEV/FCEV proportion between 2015 and 2020	60.79%	78.68%

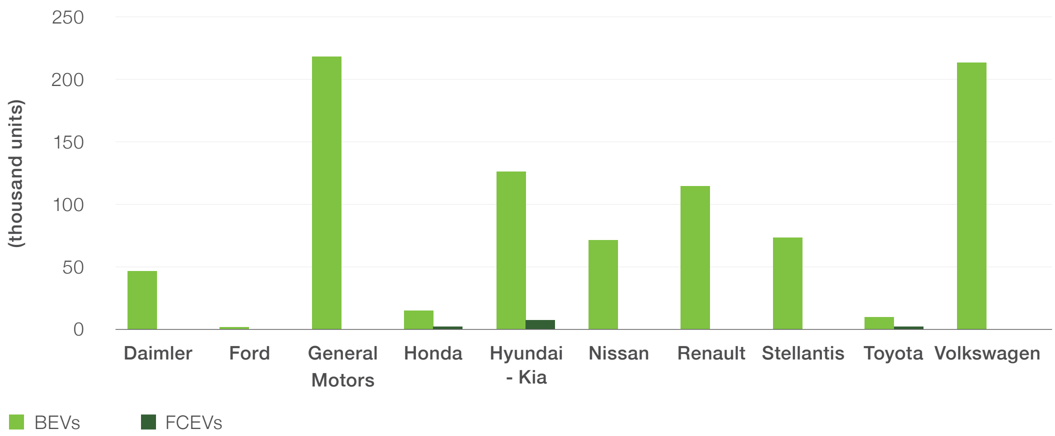
3.1.4
BEV and FCEV sales

According to sales data for 2020, both Volkswagen and General Motors sold more than 200,000 units of BEVs, leading the market (see Figure 11). It is worth noting that 58% of the sales of General Motors BEVs were from the selling of the low-cost Hong Guang Mini EV in China, and that concerns have been raised about their under par safety features.[xiii] However, Ford has a less impressive record for BEV sales, with only 491 units in the last year. The only companies selling mass-produced FCEVs between 2016 and 2020 were Honda, Toyota, and Hyundai-Kia, with 4,733, 11,120, and 12,397 units separately.

Figure 11.

Global sales of BEV/FCEVs by company in 2020 (Source: own compilation based on data from Marklines)

Figure 11.

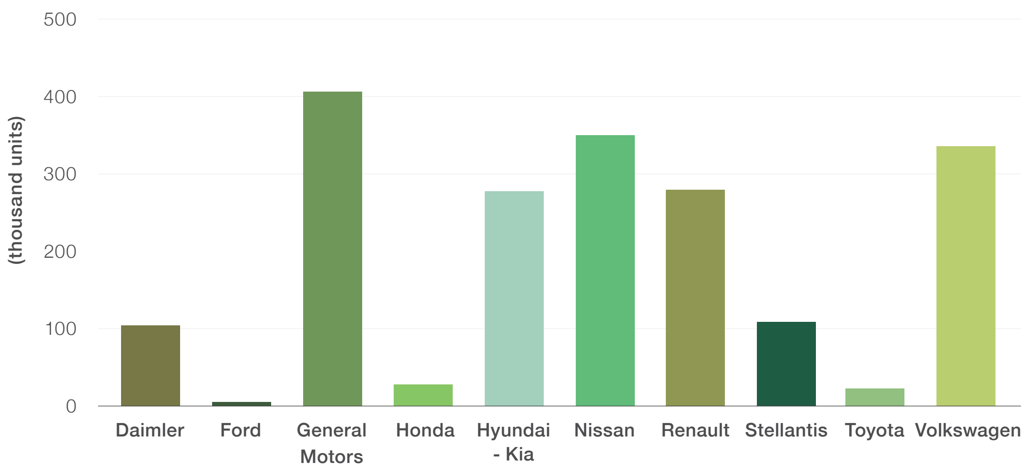


Ford, Toyota, and Honda have all performed poorly on sales of BEV/FCEVs in the past five years (see Figure 12). Ford is not keen on non-ICE technology and remains uninvolved in the EV race, with cumulative sales of BEVs in the past five years as low as 3,984 units.

Figure 12.

Cumulative sales of BEV/FCEVs between 2016 and 2020 by company (Source: own compilation based on data from Marklines)

Figure 12.



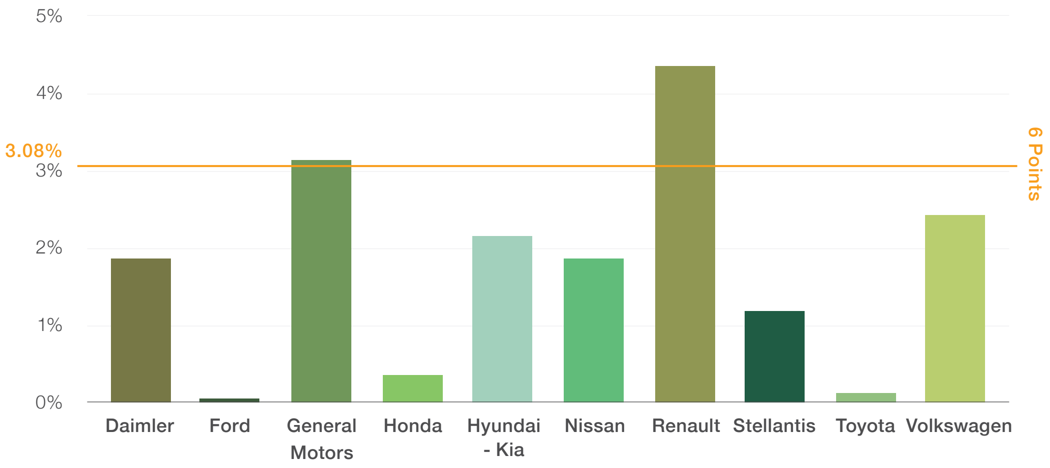
xiii Refer to Appendix 2: company profiles – General Motors

The percentage of BEV/FCEVs sold by Ford (0.01%), Toyota (0.12%), and Honda (0.35%) in 2020 was less than 1% (see Figure 13) of their total vehicle sales. All three companies are therefore lagging behind in the transition to BEV/FCEVs.

Figure 13.

BEV/FCEVs sold in 2020, as a percentage of global sales (Source: own compilation based on data from Marklines)

Figure 13.

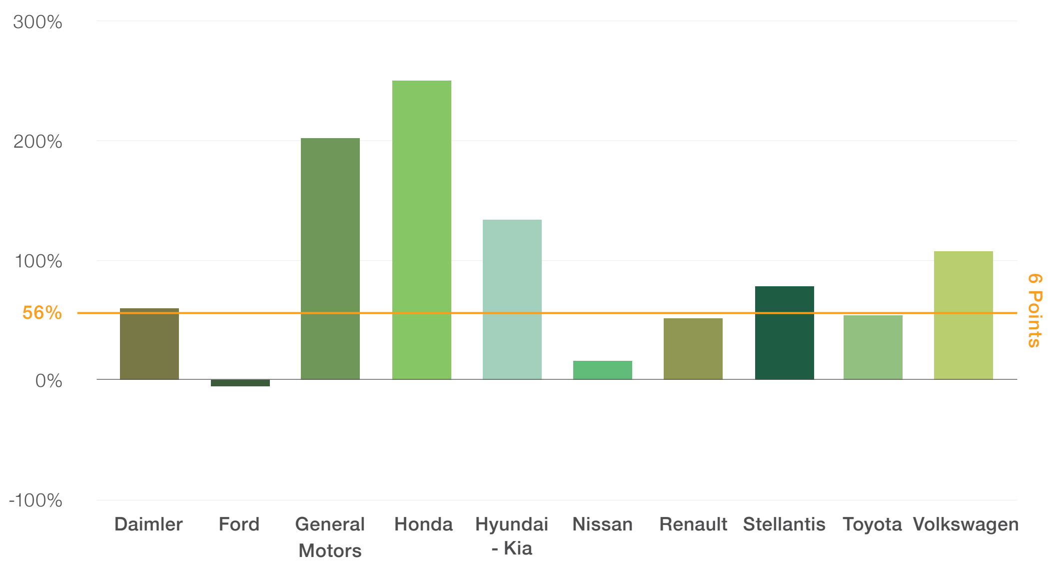


Nevertheless, the percentage of BEV/FCEVs sold by Honda is growing rapidly, with about 250% compound annual growth rate between 2016 and 2020. General Motors also maintains its lead, with a compound annual growth rate for BEV/FCEVs of over 200%. In contrast, the percentage of Ford's BEVs has shown negative growth over the past five years (see Figure 14).

Figure 14.

Compound annual growth rate for BEV/FCEVs as a percentage between 2016 and 2020, by company (Source: own compilation based on data from Marklines)

Figure 14.



3.2 Supply chain: a source of high GHG emissions

In addition to controlling emissions from the use of vehicles, it is impossible to address the contribution that vehicles make to the climate crisis without also reducing the carbon footprint of production facilities and suppliers. Until now, there has been insufficient attention on emissions from the supply chain. Emissions from the supply chain are projected to increase in the future, considering the passenger car industry's electrification transition. This section examines the performance and plans of carmakers to decarbonise their supply chain.

3.2.1 Carbon intensity

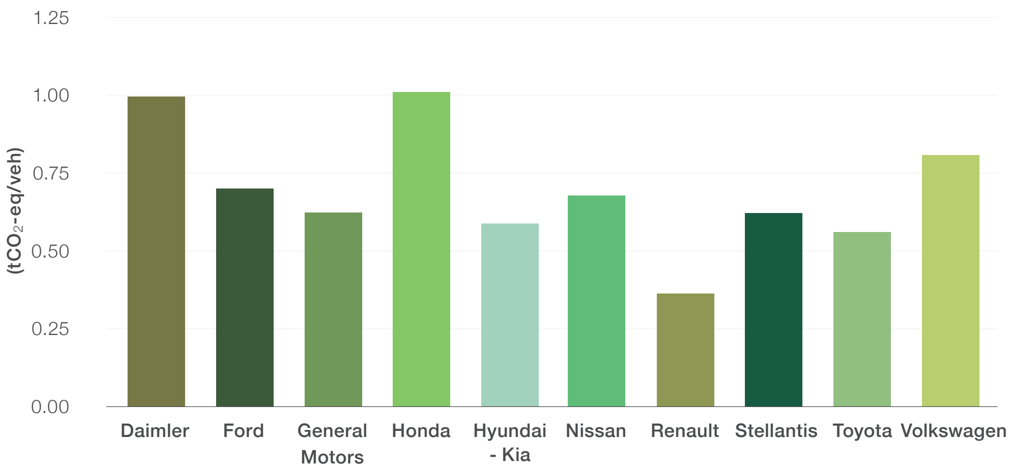
Looking at the companies' self-reported data, Renault performs well in reducing carbon emissions in the supply chain, with a relatively good Scope 1 and Scope 2 GHG emission intensity (0.35 tCO_2-eq/veh) and upstream suppliers' emission intensity (4.64 tCO_2-eq/veh), compared to other companies. Daimler and Honda are lagging behind. Daimler's Scope 1 and Scope 2 GHG intensity is significantly higher than most companies, at 1 tCO_2-eq/veh. Honda's overall performance on decarbonising the supply chain has been unsatisfactory, with high Scope 1 and Scope 2 GHG emissions intensity (1.01 tCO_2-eq/veh).

It is also imperative to consider the emissions intensity of the automobile production process to make meaningful comparisons between the companies. As Toyota's Scope 1 and Scope 2 GHG emissions in 2020 are not available, its emission data in 2019 are therefore used for the evaluation. In 2020, PSA (which belongs to Stellantis) performed well for its Scope 1 and Scope 2 GHG intensity (0.29 tCO_2-eq/veh). However, FCA (which also belongs to Stellantis) has a poor performance (0.80 tCO_2-eq/veh). Amongst all the companies, Honda and Daimler have the highest GHG intensity (see Figure 15).

Figure 15.

Scope 1 and Scope 2 GHG intensity in 2020. Toyota's data in 2020 are not available, its data in 2019 are used in this chart. (Source: own compilation based on data disclosed by companies themselves)

Figure 15.



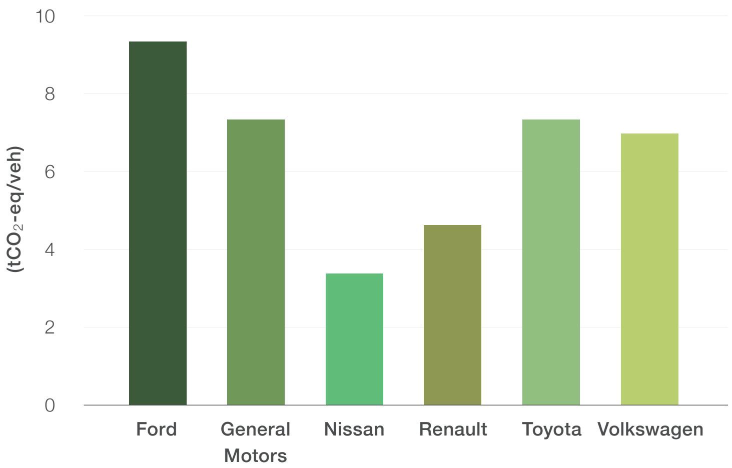
3.2.2 Disclosure and carbon intensity of upstream suppliers

The GHG emission intensity of upstream suppliers has also been examined. However, the transparency of the relevant data is unsatisfactory. Daimler, Honda, Kia (belonging to Hyundai-Kia), Stellantis and Renault have only partially disclosed their GHG emissions, and are missing information for Scope 3, and upstream suppliers' GHG emissions for Daimler, Honda, Kia (belonging to Hyundai-Kia), PSA (belonging to Stellantis) and Renualt are also not available. It is not possible to evaluate Daimler, Honda, Hyundai-Kia, and Stellantis as none of these companies disclosed their upstream suppliers' GHG emission information for 2020.[xiv] Among the car manufacturers that disclosed their emissions data, Ford performed the worst in 2020 (see Figure 16). Its average emission intensity of upstream suppliers is 9.36 metric tCO_2-eq/veh. There is ample opportunity for Ford to reduce emissions through stricter requirements for its suppliers in different tiers.

Figure 16.

Upstream suppliers GHG emission intensity in 2020. General Motors and Toyota's data in 2020 are not available, their data in 2019 are used in this chart. (Source: own compilation based on data disclosed by companies themselves)

Figure 16.



3.2.3 Carbon reduction plans

In addition to their performance on decarbonisation in 2020, the carbon reduction plans of carmakers also have to be taken into account. Amongst all the companies, Daimler, Honda, Toyota, Hyundai-Kia, and Stellantis have either quit or not joined the SBTi, a global programme which sets requirements for companies to participate in reducing GHG emissions in line with climate science. It is worth mentioning that Honda was removed from SBTi in 2021 for failing to set climate goals in good time.[57] Among the companies which joined the programme, General Motors and Ford are the only two committed to 1.5°C targets, and are ahead of other car manufacturers in terms of their carbon reduction goals. Although Mercedes-Benz set the same target, it does not include all the production of its parent company Daimler.

To conclude, the entire automobile industry is still lagging far behind on the target to stay within 1.5°C, something that it can only correct by setting, and then implementing, comprehensive and holistic decarbonisation targets. Reducing the supply chain GHG emissions for the key components used to make vehicles will be critical to tackling the climate emergency.

xiv According to previous experience, Toyota issues its Sustainability Report at the end of the year, meaning that data for 2020 will only be available in November or December of 2021.

3.3 Resource sustainability

Out of the ten companies, Nissan is the only one that has clear targets to reduce its use of raw materials and use secondary materials instead. Nissan aims to reduce new natural resource usage by 30% per vehicle in 2022, and use materials that do not rely on newly mined resources for 70% of the material used in each vehicle by 2050.[58] In terms of building battery recycling capacity, more than half of the companies have invested in this to some extent. The largest in scale is a recent project by Honda with the capacity to process 100 thousand metric tons of batteries.[59] In terms of building facilities to reuse retired batteries, Daimler is an early starter at building energy storage systems that use second-life batteries. The total scale of its facilities reach 30.2 MWh, which is higher than the other nine companies at present.[60]

3.4 Negative climate lobbying and violations of emission regulations

The evaluation reviews openly accessible reports of companies' participation in weakening climate regulations or violated emissions regulations from 2019 to 2021. Eight out of the ten companies receive a half-grade deduction to their overall score for the severity of their activities. The issues assessed in the report include resisting the tightening of carbon emission standards, lobbying to delay full-electrification policies, and efforts to hold back technology to reduce harmful emissions. Companies always form alliances or hide behind industry associations when they try to weaken regulations. However, there is increasing public attention on such lobbying efforts by the automotive industry. For example, Toyota's investors have put pressure on the company to stop its negative anti-climate lobbying activities; Toyota had to respond with a promise to review and be more transparent about its lobbying activities.[5]

4
Where to from here?

4.1
ICE phase-out: the climate will not wait

4.1.1
Hesitancy in committing to a carbon-free transition

In a broader sense, automakers have not taken enough decisive actions towards the carbon-free transition. With its focus on gasoline car sales, the entire automobile industry has been slow to turn to BEV/FCEVs. Firstly, the number and proportion of BEVs and FCEVs being made as a percentage of total vehicles, are still too low. There are currently 12 million passenger EVs on the road, and even though this figure also includes HEVs and PHEVs, this still represents only 1% of the global fleet.[61,62] Most new cars sold today still run on climate-destroying gasoline or diesel. In particular, the leading manufacturers of ICE vehicles have not adapted quickly enough and have been unwilling to commit fully to BEV/FCEVs. To tackle climate change, carmakers need to invest more in the development of a fleet that excludes internal combustion engines.

Secondly, the global market is dominated by the current generation of gasoline-electric hybrids, which shows that companies are also reluctant to give up their vested interests. While investing in all-electric vehicles, they still want to leverage their huge investment in existing technology. For example, some Japanese companies, such as Toyota, are confident that hybrid technology is an effective alternative to the internal combustion engine.[63] However, the real-world emissions reduction and fuel economy of hybrid vehicles are not as good as expected. According to an analysis, a plug-in hybrid vehicle only delivers an emissions reduction of about a third of a typical petrol or diesel car, which is far less than the official estimates.[4] Another analysis predicts that with very little advantages for fuel efficiency and carbon emissions, plug-in hybrids will be quickly surpassed by BEVs on price, performance and overall consumer appeal.[55]

Thirdly, **many car manufacturers are trying to slow down the process of banning ICE vehicles through their lobbying activities.**[64] The Japan Automobile Manufacturers Association (JAMA) has been lobbying against the complete phase-out of PHEVs. The chairman of JAMA and Toyota Motor, Akio Toyoda, has lobbied for Japan to continue to sell cars with internal combustion engines. The association and Toyota not only show no intention of ending their reliance on fossil fuels, they are stepping up their efforts to promote hybrids.[63,65] In the United States, many companies sided with Trump and supported rollbacks in federal GHG and NHTSA's Corporate Average Fuel Economy (CAFE) standards for vehicles in the hope of continuing to sell fossil fuel-powered vehicles. General Motors and Nissan exited the lawsuit over California's authority not long after Biden's victory.[66] However, Toyota, Stellantis, and Hyundai-Kia did not drop their support for the Trump lawsuit until 2021.[67,68] In 2021, automotive manufacturer associations in Europe tried to lobby against the Euro 7 emission rules which would help clean up the dangerously polluted air that millions of Europeans are exposed to.[69] Despite their claims of dedication to climate goals, what they are actually doing is opposing fossil-fuel vehicle phase-outs, and slowing down the pace of decarbonisation.

4.1.2
Hydrogen fuel cell electric vehicles

Another alternative technology is the hydrogen FCEV. However, there are questions about its energy efficiency for use in passenger cars. Despite this, some companies are promoting hydrogen FCEVs. In Europe, Renault is offering hydrogen fuel cells to equip light commercial vehicles. The company has also set a goal to become a leader in hydrogen-powered light commercial vehicles in Europe by 2025.[70] In Asia, Hyundai and Toyota are proactive in developing and commercializing hydrogen power by promoting fuel cell technologies. Hyundai has already released fuel cell SUVs and mass-produced trucks, and is planning to build more models in the next three years.[71] Also, the company aims to popularize hydrogen as a familiar and widely used energy by 2040.[72] Toyota is also planning to build three more new models of hydrogen powered cars by the end of 2022.[73] Even though Honda plans to stop production of the Clarity fuel cell car in 2021,[74] it is not dropping plans for the technology in the coming years.[75]

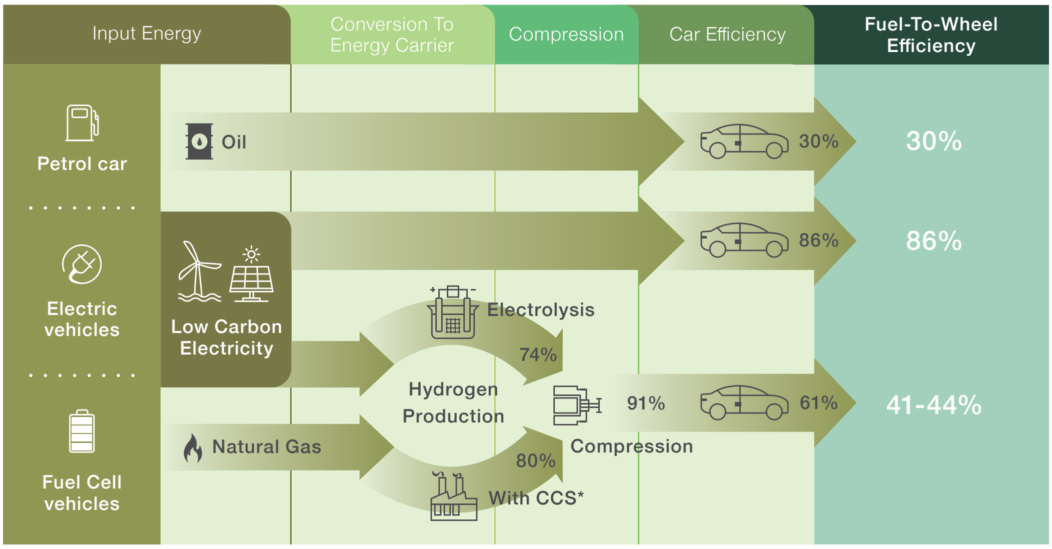
As for other automakers, there is no sign that they are seriously looking into fuel cell passenger cars and taking FCEVs as a feasible option. Volkswagen's CEO has also commented that the FCEV is not proven to be a climate solution because of its inefficiency.[76] Indeed, the environmental benefits of FCEVs are still controversial.

The major doubts about FCEVs centre on energy efficiency. Not only is hydrogen produced through energy-intensive processes, the fuel cell system which converts hydrogen to electricity to power a motor is not energy efficient either. Fuel cell vehicles are only half as efficient as BEVs (see Figure 17).[77]

Figure 17.

Relative efficiency of BEVs vs. electrolytic hydrogen FCEVs (Source: Climate Change Committee, CCC)[77]

Figure 17.



* Carbon Capture and Storage
% Indicates conversion efficiency at each stage

Notes: The diagram shows the indicative efficiency of using a given amount of zero-carbon electricity in powering a car. Whilst in practice each of the efficiency numbers could vary, this would not be sufficient to change the conclusion that electric vehicles provide a much more efficient solution for powering vehicles than use of electrolytic hydrogen in a hydrogen fuel cell vehicle.

Furthermore, almost all of the hydrogen used today is extracted from methane gas, which requires a lot of energy and emits vast amounts of carbon dioxide. Although fuel cell technology might not seem promising for the application of passenger cars, some experts still believe that hydrogen could be useful in heavy vehicles and aviation, and essential in decarbonising other sectors, such as steel production.[78]

4.1.3 Resolute action to end the sale of ICE vehicles

In summary, road transport is still not on track for carbon neutrality. Carmakers are not doing enough to decarbonise their fleets. For example, as the world's best-selling automaker in 2020, Toyota's global CO_2 emissions were 5.68 million metric tons, which is the same as the amount of carbon sequestered annually by almost 40,000 acres of forest preserved from deforestation. Therefore, a more rapid ICE phase-out is an essential step toward decarbonising the road transport sector. Auto manufacturers' efforts to end the use of ICE vehicles are an important long-term opportunity for reducing GHG emissions. Their commitments are crucial market signals, which set in motion an urgently needed systemic transformation and make significant impacts on decarbonising road transport. In brief, all corporations need to raise their game and join in a collective effort to put the vehicle industry on a pathway to delivering GHG reductions in line with what is needed to meet the ambitions of the Paris Agreement.

The leading automobile companies hold the key to the future of zero-carbon mobility. The ten best selling automakers share about 80% of the global market. These top car manufacturers should therefore take social responsibility for action on the climate, to match their penetration of the global market and their advantage of scale. These companies should make more ambitious commitments and take even faster action to reduce GHG emissions.

Meanwhile, as part of their Covid-19 stimulus measures, countries are spending $14 billion to support electric car sales, up by 25% from 2019, with many of them providing heavy subsidies to purchase EVs.[79] While automobile manufacturers are benefiting from the stimulus, they must ensure that workers' rights are also protected in the transition (See Box 2).

Box 2:
Securing economic prosperity for workers and communities

As companies and governments navigate the transition to carbon-free transportation, the stakes are high, not just for the environment and our global climate, but also for the workers and communities who have powered the sector for over a century. These workers have provided prosperity for shareholders and mobility for billions of people around the world, and yet they stand at a similarly uncertain crossroads as our planet.

A global scan of the history of major economic transitions shows that while transition in manufacturing and industrial activity is inevitable, justice for workers is not. In September 2021, opinion editorial in The Hill, Ray Curry, the President of the United Auto Workers union (UAW)[xv], shared the following assessment of this moment:[80]

> ***"We have that opportunity right now in the auto industry as we transition from internal combustion engines to electric vehicles. This is a necessary shift, and one our union supports. Auto workers — like all Americans — want a country and a world where our children and communities can thrive. Electric vehicles are one of the critical ways to achieve that. This transition can benefit the environment, workers, and our communities alike. Too often, those interests are pitted against each other by corporations which are ultimately guided by their need for profit. It doesn't have to be this way."***

Automakers and policy makers must leverage all tools at their disposal to manage the phase-out of ICE vehicles, while engaging early and often with workers, unions and labour organisations and other stakeholders. They have the responsibility to plan for robust investments and policies that will ensure a "just transition" to protect these workers and surrounding communities' economic, social and physical health and well-being, including the creation of thousands of new union jobs.

For example, this report from the United Auto Workers outlines a series of "Policies to Protect Displaced Workers" (p.28), including commitments from employers to re-tool plants and retrain workers, and to provide strong support during transition periods. This should happen alongside "robust government jobs programs to guarantee quality jobs for all those seeking work."[81]

Automakers should agree to a "majority sign-up" (or "card check") and "neutrality process" that allows their workers to freely decide on joining a union. They should also commit to high industry workplace standards that match or exceed standards that the UAW has established through collective bargaining with the "Big 3" US automakers – General Motors, Ford and Chrysler (belonging to Stellantis). In addition, automakers must commit to "insource" EV work (e.g. battery manufacturing) to minimize job losses that result from the transition from ICE to all-electric vehicle production.

Depending on the national and regional contexts and labour laws, the available measures will vary, however many of the principles behind these policies for industrial transition could apply alongside bold investments and expansion of social safety net programmes and commitments to ensure that workers have a voice on the job.

xv The UAW is an international labor union which represents 400,000 active members and over 600,000 retirees in the United States, Canada and Puerto Rico.

4.1.4
ICE phase-out before 2030

We demand that leading global automakers end the sale of ICE vehicles in main markets (US, China, Korea, Japan) before 2030. For the EU, this needs to happen by 2028. This is the key to achieving the low-carbon transformation of road transportation and preventing the worst effects of climate change.

According to an analysis by ICCT, electric vehicles are the single most important technology for decarbonising the transport sector. The sales of EVs[xvi] will need to reach between 35% and 75% of the global market by 2030, with higher levels in major markets, to achieve the Paris Agreement objectives to limit the global temperature increase to "well below" 2°C this century.[3] Similarly, Bloomberg NEF states that global sales of new ICE vehicles across all segments need to be phased out by 2035 to stay on track for the Net Zero Scenario.[55] Even the IEA, an organization that has been relatively conservative on energy transition, suggests that halting global sales of new internal combustion engine passenger cars by 2035 could benefit a shift away from fossil fuels.[82]

Considering that the ten best selling automakers make up about 80% of the global market, their progressive action to phase out ICE vehicles by 2030 is imperative. This transition is the biggest and only opportunity that the industry has to combat climate change. Taking this progressive action will provide a clear signal to all automotive manufacturers, suppliers, investors, and public sectors to move towards a zero-emission transport system in order to build a clean future. Now, there is no time to lose.

xvi ICCT does not give a clear definition of EVs in the paper, so this figure could include PHEVs.

4.2

Curb steel consumption before zero-carbon steel is available

4.2.1 **Decarbonising steel is crucial**

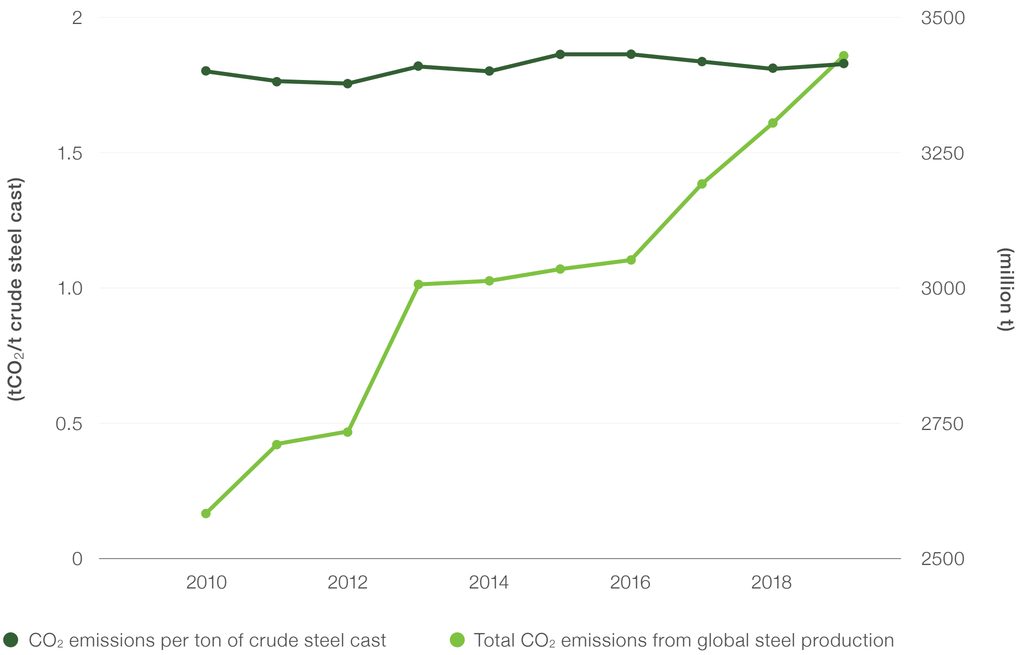
Steel is one of the most critical materials in today's society and it is present in almost every aspect of our daily lives. This also applies to the automobile industry. According to data from the World Steel Association, around 10% of steel is used in car production every year and the average weight of steel in a car is 0.9 metric tons, which is the dominant material used in cars.[83] Therefore, decarbonising the steel sector is crucial for decarbonising vehicles and aligning with the Paris Agreement target. However, in this era of transitioning to low carbon technologies, the steel sector is going against the trend.

During the past ten years, CO_2 emissions from steel production have risen sharply because of the continuous increase in steel production. As shown in the figure below, the emission of CO_2 per crude steel cast unit has kept steady around 1.8 metric tons, while the amount of steel produced has increased by 30% compared to 2010 (see Figure 18).

Figure 18.

CO_2 emissions per metric ton of crude steel cast and total CO_2 emissions from global steel production (Source: own compilation based on data from World Steel Association)[11]

Figure 18.

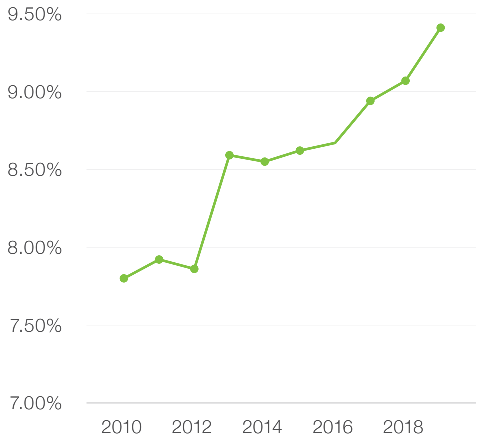


What's more, the growth of CO_2 emissions from steel production is faster than that of global CO_2 emissions. In 2019, CO_2 emitted by steel production accounted for 9.4% of the global CO_2 emissions (see Figure 19).[11] Currently, the steel sector is the one of the dominant contributors to CO_2 emissions in all sectors with no sign of slowing down. That makes it an obstacle on the path to carbon neutrality.

Figure 19.

The growth in the percentage of CO_2 emissions contributed by steel production (Source: own compilation based on data from Our World in Data and World Steel Association[11,83])

Figure 19.



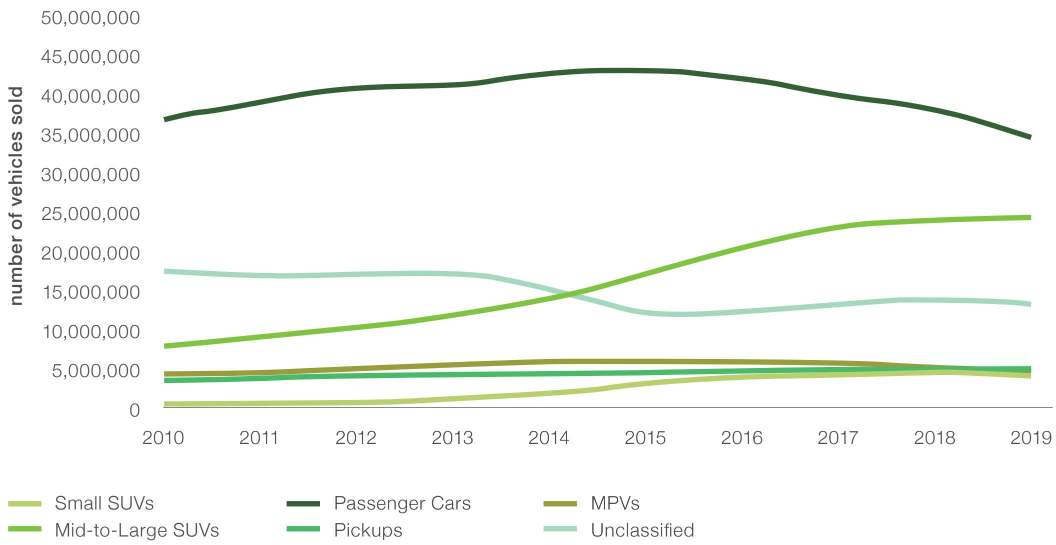
4.2.2 SUVs: more fuel and more steel

In recent years, SUVs have become increasingly popular across the world. Passenger car sales peaked in 2015 and then declined after that. Despite this, the SUV category has grabbed the lion's share of global sales (see Figure 20), with a threefold increase between 2010 and 2019. Today, almost half of all cars sold in the United States and one-third of the cars sold in Europe are SUVs. The data from IEA depicts that SUVs account for 42% of the global market share for cars in 2020.[84] It is estimated that the production of SUVs will grow to 52% in 2027. Even within EV production, in 2027, 63% will be SUVs.[85] However, such a scenario would make reducing GHG emissions to within the agreed targets impossible to achieve.

Figure 20.

Global vehicle sales by type between 2010 and 2019 (Source: Refinitiv)[86]

Figure 20.

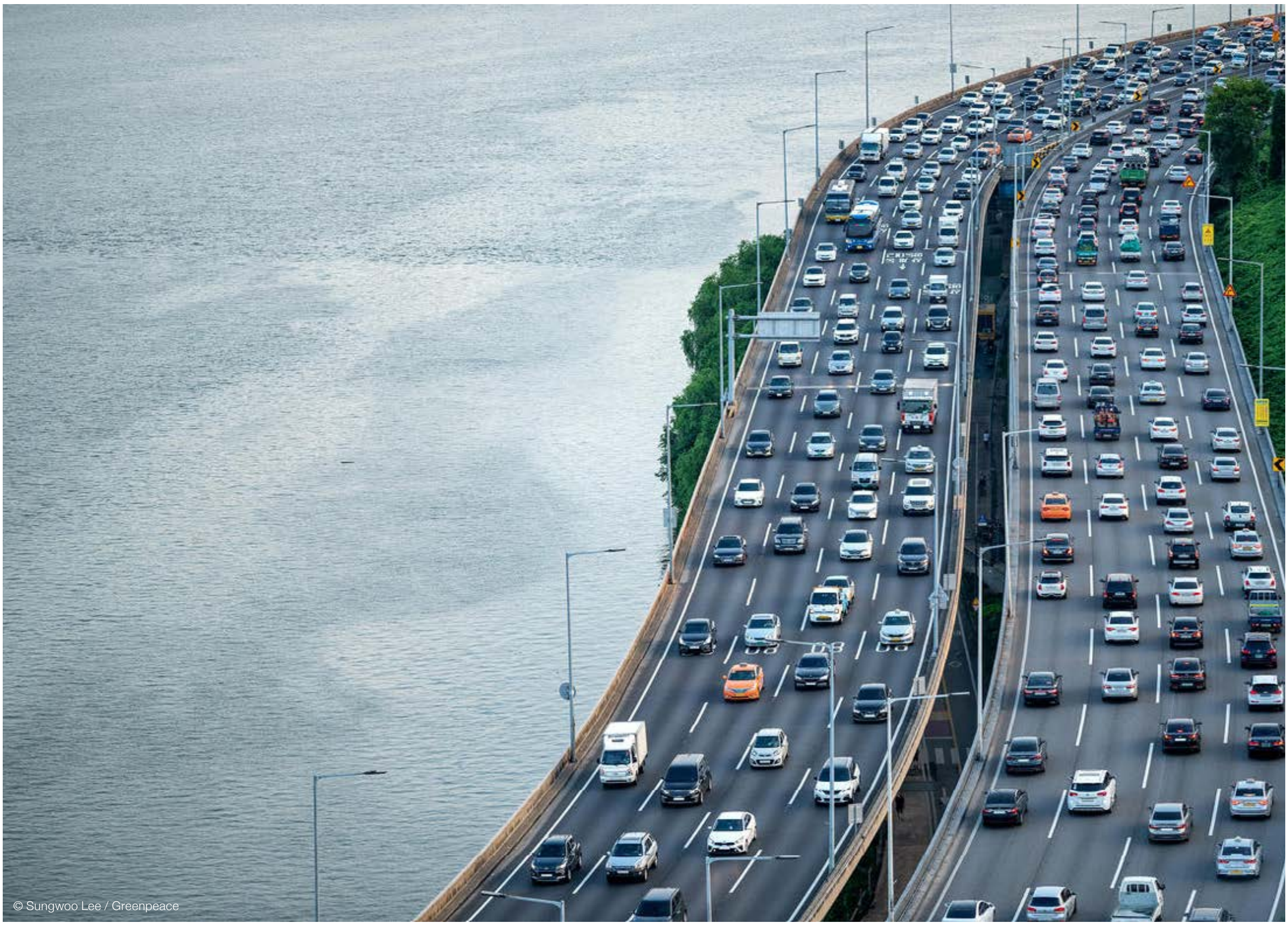


Not only do SUVs on average consume about a quarter more energy than medium-size cars, they drive the increase in the automotive industry's demand for steel. Because of their larger size and poor aerodynamics, SUVs release more tailpipe emissions. They are also the source of more carbon emissions during the production phase, making SUVs the second largest cause of rising CO_2 emissions between 2010 and 2018, ahead of heavy industry, trucks, aviation and shipping.[87]

In general, the average SUV or pickup truck uses 20% more steel than the average car.[7] The trend for fleet "truckification" will no doubt be a challenge for reducing emissions in the car market, although very lucrative for steel makers.

For example, Volkswagen's SUV model, Tiguan, contains an estimated 900 kilograms of steel and approximately 150 kilograms of aluminium. Instead, Volkswagen's Golf requires only 700 to 750 kilograms of steel and 100 to 120 kilograms of aluminium. If you look at how the total sales have developed for these two cars alone, the extent of the higher raw material consumption by SUVs becomes clear. Since 2018, Volkswagen has been producing more Tiguans than Golfs; the increased SUV production means a considerable increase in demand for these metals. In the past five years alone, the production of Volkswagen Tiguan SUVs required at least 115,350 metric tons more aluminium and 576,000 metric tons more steel than the production of Volkswagen Golf cars. The production of one metric ton of steel releases approximately 1.8 tCO_2. The additional consumption of steel by the Volkswagen Tiguan compared to the Volkswagen Golf has therefore led to an additional one million tCO_2 released into the atmosphere in the past five years alone.[7]

Aside from GHG emissions, other impacts have been documented from the mining of raw materials for steel such as land grabbing, higher water and land consumption as well as environmental destruction.[88] The iron ore required for steel production is also linked to environmental disasters such as the burst dam in Brumadinho, Brazil, in which at least 259 people lost their lives, in 2019.



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4.2.3
The unclear path to the decarbonisation of the steel industry

Clean technologies that effectively reduce carbon emissions in the steel sector are still at an early stage of development.

At present, the most widely used method of producing steel is called BF-BOF. The BF-BOF process is carbon intensive, it emits about two tCO_2 per metric ton of steel produced. The hydrogen-based DRI/EAF steel production process is a potential technology to decarbonise the sector. However there is still a huge challenge in producing low-carbon hydrogen.[89]

Over 95% of the world's hydrogen is currently produced using the steam methane reforming process (SMR). Greenhouse gas emissions from the production of hydrogen can be separated into two parts: (a) the SMR process and the subsequent water gas shift (WGS) reaction in which methane is converted to carbon dioxide and hydrogen; and (b) the energy used to generate the heat and high pressure needed for the SMR process.[90] The CO_2 emissions from the production of hydrogen lie somewhere between natural gas and coal fired power.[91] If fugitive methane emissions are also considered, the total emissions for the whole hydrogen production process could be as high as 550.8g CO_2-eq/kWh.[92]

Green hydrogen is produced by electrolyzing water using surplus renewable energy. This is believed to be the ultimate solution to producing carbon-free hydrogen and the answer to zero-carbon steel. However, the process requires significant amounts of surplus renewable energy. Obtaining sufficient and low-cost electricity from renewable energy sources will be the key challenge. At present, the cost of green hydrogen is 3-4 times as much as that of grey hydrogen.[93] In the long term, the price of green hydrogen is expected to reduce together with the development of renewable energy infrastructure. Although some predictions project that green hydrogen will be cost competitive with hydrogen made by fossil fuels with carbon capture and storage by 2030,[94,95,96] practically speaking, relying on green hydrogen is not a speedy solution to rescue the climate crisis from carbon intensive steel production.

4.2.4
Urgency of reducing steel consumption in car manufacturing and developing zero-carbon steel

Considering that steel is contributing to an increasingly large proportion of global carbon emissions, while decarbonising steel is not yet viable, we need to curb the growth of steel production and consumption in the automobile sector immediately, in order to save the climate.

On the one hand, material efficiency should be improved. Taking the automobile industry as an example, this can be achieved through minimizing steel use in the car body and reducing the production of heavy cars, such as SUVs. As manufacturers, the car companies have the responsibility to redesign their products. On the other hand, the use of end-of-life (EoL) steel should be promoted more. Recycled steel production uses about 50% of the energy of primary steel and currently makes up 23% of current production.[97] It can be further decarbonised if it's recycled using renewable energy. There is no doubt that secondary steel can make a great contribution to the low carbon transition especially in countries with high steel consumption, yet improving the quality of secondary steel could be a challenge.

Policy makers need to step up, and formulate more stringent policies and standards to limit the use of carbon-intensive steel in products. Moreover, governments can support and promote products that employ green steel and reduced life cycle GHG emissions through government procurement and incentives for the public. As the green steel industry is at an early stage, governments need to provide tax incentives to encourage companies to invest. This would be a good opportunity to divert the money currently spent by many governments subsidising fossil fuels, towards transforming the steel industry to take us beyond "peak steel".

4.3
Electric vehicles are not the end of the story

4.3.1
Renewable energy is the key

Nowadays, many countries and regions consider the electrification of vehicles as an important strategy for carbon neutrality in the transportation sector. Among them, China, the EU and the US are pioneers in the popularization of electric vehicles. It is estimated that the annual sales of electric vehicles in these three markets will reach 30 millions, and the global market share of electric vehicles will exceed 30% by 2030.[9]

Compared with ICE vehicles, the life cycle GHG emissions of battery electric vehicles are much lower.[98] In other words, the transition from ICE vehicles to BEVs is a significant step towards carbon neutrality in the transportation sector. However, simply producing BEVs will not achieve the 1.5°C target of the Paris agreement. To further reduce the life cycle GHG emissions, a BEV should be charged with renewable energy.

Taking medium-size BEVs as an example, the GHG emissions during use represent the majority of the life cycle GHG emissions. In this context,

the importance of decarbonising electricity production cannot be ignored. Transforming to renewable energy is imperative to making EVs truly zero-emission.

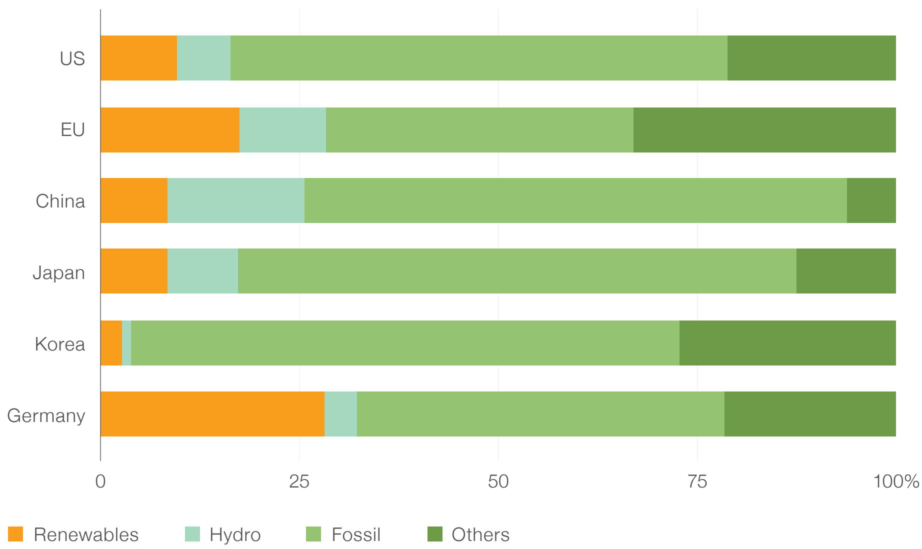
The carbon emission intensity of the power generation technology determines the cleanliness of electricity used by the vehicles. Compared to electricity produced by fossil fuels (coal, oil and natural gas), the CO_2 intensity of power generation through renewable energies like photovoltaic (PV) and wind power is dozens of times lower.[99]

GHG emissions from electricity production can differ widely in different countries and regions because of the difference in energy mix. When it comes to electricity production sources, fossil fuels generated 37% of the electricity in the EU in 2020, while the number in India is 61%.[100] The energy mix in major EV markets still contains a high proportion of fossil fuel. Increasing the deployment of renewable energy is the key to truly decarbonise BEVs (See Figure 21).

Figure 21.

Electricity mix of key EV markets (Source: own compilation based on data from IEA)[101]

Figure 21.



4.3.2
Benefits of reuse and recycling batteries

Resource supply risks

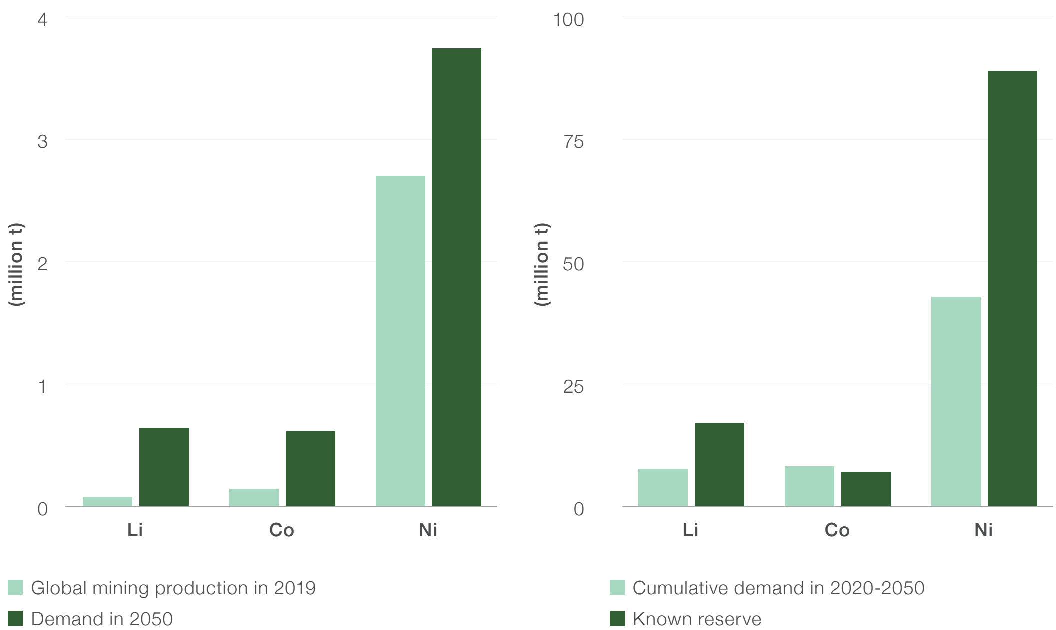
Reuse and recycling of batteries could also help ease the supply risks of resources. At present, EV battery production is concentrated in Asia, while the critical materials are concentrated in other regions. This creates supply risks. During the past five years, CATL, Panasonic, LG chemistry, BYD and Samsung SDI have dominated the global EV battery market; more than 70% of EV batteries were produced by these five companies. However, these Asian countries rely on importing critical materials from other countries. DRC, which has more than half of global cobalt reserves, produced 71.4% of cobalt in the world in 2019. Similarly, lithium resources are also highly concentrated; in 2019, almost four-fifths of global lithium were produced in Australia and Chile.[102]

By 2050, the global mining of raw materials is projected to increase from 2019 levels by a factor of 8.3 for lithium, 4.4 for cobalt, and 1.4 for nickel (see the left figure of Figure 22), if these materials are only used for the EV battery sector. When compared with current known reserves, cobalt reserves could be depleted before 2050 by the demand for EV batteries alone (see the right figure of Figure 22), while the demand for lithium and nickel could consume 45% and 48% of known reserves, respectively. This would require a dramatic increase in the supply of these materials in the future and is likely to pose supply challenges for the EV battery industry.

Figure 22.

Comparison of the projected demand by 2050 for EV battery materials with the 2019 global production from mining (left) and comparison of the cumulative demand between 2020-2050 with the known reserves (right). (Source: own compilation based on data from open data from Xu, C. et al. and USGS)[103,37]

Figure 22.



Resources are in short supply, especially for the main battery producers in Asia and the top BEV markets like China, the EU and the US. Reusing and recycling retired EV batteries will not only release the recycled material supply potential in these countries and regions but also alleviate the environmental pollution caused by over-exploitation in origins.

Reduction of carbon emissions

In addition to reducing demand for primary materials, the reuse and recycling of EoL batteries is also beneficial for reducing the life cycle GHG emissions of BEVs.

EV battery production is associated with diverse environmental impacts along a complicated supply chain. The production of raw materials, including mining, refining and smelting, is important to consider, and could account for 50-60% of the GHG emissions from battery cell production. However, this could be reduced through effective materials recycling.

The projected volumes of battery materials needed by 2050 will lead to significant emissions of GHGs: in the worst case scenario, the CO_2-eq that could be released is 37.4 million metric tons for nickel, while for cobalt the figure is 10.3 million metric tons and for lithium it is 3.1 million metric tons. Under a 100% recycling efficiency scenario, the CO_2-eq could be reduced to 25.5 million metric tons for nickel, 6.1 million metric tons for cobalt, and 2.1 million metric tons for lithium by 2050.[37]

In an enhanced recycling scenario, if the collection rate could reach 65% by 2025 and 70% by 2030, while the EU's material recovery targets could be realised globally in time (taking a road between no recycling and 100% recycling. GHG emissions could be reduced by 22% for lithium, 33% for cobalt, and 26% for nickel by 2050, compared to the scenario without recycling (see Figure 23). Depending on the collection rates and materials recycling efficiency, the scale of GHG emissions reductions may change in the future.[5]

Figure 23.

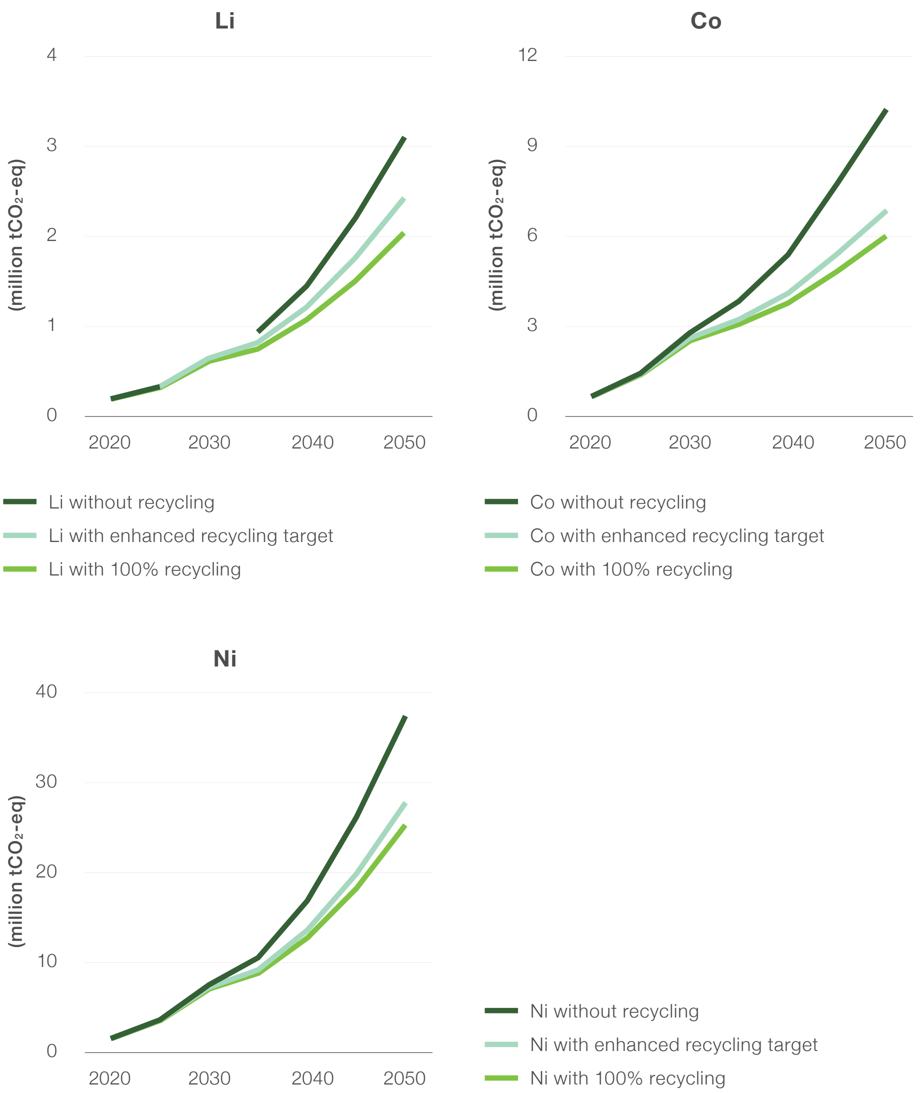


Figure 23.

GHG emissions from the primary demand for Li, Co, Ni for EV batteries up to 2050 globally. GHG emissions under three scenarios, including GHG emissions without recycling, with 100% collection and recycling, and in line with ambitious and achievable targets (enhanced recycling target) for collection and recycling. For the enhanced recycling scenario, for 2030-2050, we assume that the collection rate will reach 80%, and the recycling rate will reach 80% for lithium, 100% for cobalt, and 100% for nickel (Source: own compilation based on data from Xu. et al.)[37]

4.3.3
Reduce, Remanufacture, Recycle

Remanufacturing and repurposing can also extend the lifespan of batteries. Given that performance degradation is not evenly distributed across all the cells of the battery, refurbishing battery packs for EV applications by replacing inferior cells or modules and reassembling unaffected parts into new battery packs is a good option. Repurposing seeks to use old batteries in areas other than EVs. Batteries with a performance lower than 80% may be suitable for non-vehicle applications, especially for stationary storage.[104] A report issued by Greenpeace East Asia shows that **repurposing batteries could save 63.34 million metric tons of carbon emissions from the avoidance of new battery manufacturing.**[105]

Generally, the benefits of repurposing used EV batteries are obvious. After their second, repurposed lives, EoL batteries should be recycled to recover the potential of critical minerals inside. Therefore the rates of repurposing and recycling should be prioritized. In addition, developing new technology to extend the durability of batteries and looking for alternative materials for batteries that have lower environmental impacts are critical for all car and battery manufacturers from now on.

Policy makers should also set targets for battery producers on using a proportion of recycled materials in their new batteries and work toward a 100% recycled material product in the future. To achieve this target, governments should impose taxes on the use of raw materials and give incentives to companies that use recycled materials.

Finally, research and development should not only aim at improving battery performance, but more importantly, consider the full environmental impact of the battery's whole life cycle, with the goal of reducing resource consumption, carbon emissions and other environmental impacts, and improving the efficiency of repurposing and recycling.

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5

A vision splendid: rethinking the future of mobility

Many governments are pouring money into the automotive industry as a critical part of their Covid-19 recovery strategies. As part of its pandemic-related response, the EU accelerated the roll-out of electric mobility through adding $870 billion as stimulus measures to the Next Generation EU and Recovery Plan, including 37% of the funds from the EU Green Deal.[106] In the summer of 2021, the US President called for $174 billion in government spending to boost EVs, including $100 billion in consumer incentives.[107] Japan also doubled its subsidy for purchasing electric vehicles, a total of about $70 million in related expenses was earmarked in the fiscal 2020 third supplementary budget plan.[108]

As argued in previous sections, zero-carbon steel is not yet a viable solution, while the production of batteries for BEVs will inevitably be resource intensive. The production of new cars will continue to consume energy, resources and space. Therefore, the phase-out of ICE vehicles must be accompanied by a reduction in the overall size of the fleet in order to achieve a meaningful climate impact. **We should beware the peril of a growing market for cars in the name of phasing out the internal combustion engine.**

5.1 The environmental burden

The number of cars sold in the past 15 years totals 1.2 billion[109,110] at a growth that is similar to the growth in the world's population during the same period. And this will continue. Annual sales of passenger cars are estimated to reach 97 million vehicles by 2030, growing by 30% from 2021.[111]

Carbon emissions from car manufacturing are high. From mining the raw materials, producing components, to assembling, the carbon emissions for manufacturing an ICE car are 6t CO_2-eq on average, while the production of a BEV, including the battery, is 8-9.4 tCO_2-eq on average.[12]

When renewable energy dominates the electricity mix, it is estimated that driving a BEV in 2030 could greatly reduce carbon emissions from the whole life cycle to a quarter of the amount that would be released by ICE cars. However, once we reach that scenario, the production of cars and batteries would make up half of the carbon footprint of the whole life-cycle of cars.[17] At that point, the only way to bring down the carbon footprint would be to reduce the number of cars.

In terms of resource consumption, a Greenpeace East Asia study found that more than 2.1 TWh EV batteries fitted in new passenger cars will be sold globally in 2030. Together with this growing demand for batteries, the demand for materials could increase by factors of around 18 for lithium, 17 for cobalt, and 28 for nickel between 2020-2050, accompanied by further increases in GHG emissions from their production. By 2030, the cumulative use of cobalt within 10 years is expected to exceed 2.05 million metric tons, equivalent to 30% of the proven mineable cobalt reserves in the world.[105]

5.2
Rethinking private car ownership

The utility of private vehicles is too low to justify the necessity of personal car ownership. Most of the privately owned cars are idle 94-96% of the time.[112] Not only is this a waste of production energy and resources, it is also a waste of space.

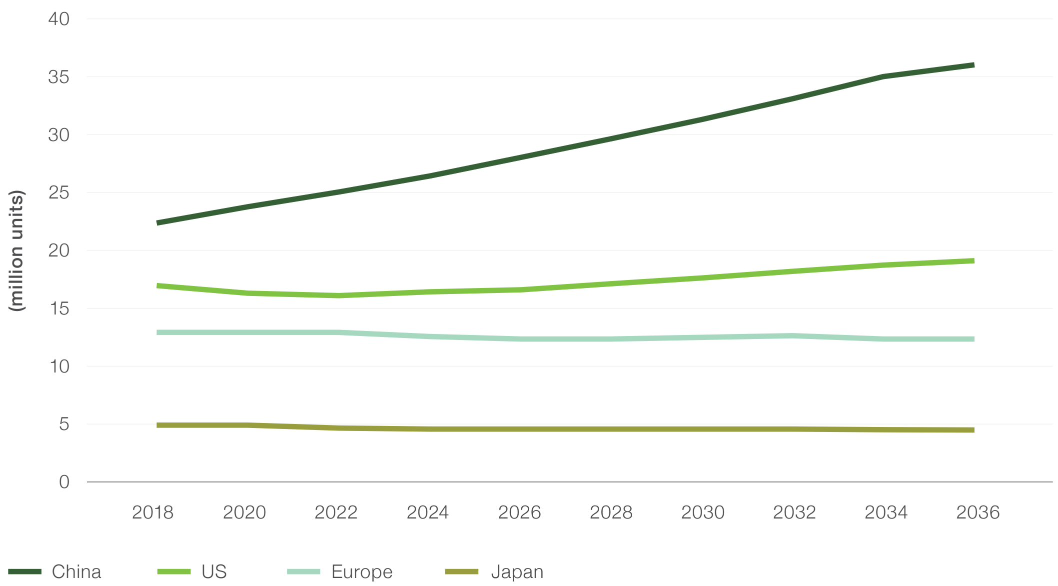
Taking the US as an example, there are a billion parking spots across the country, four for every car in existence. Plus, there are all the paved roads crisscrossing our cities: many downtowns devote 50 to 60% of their scarce real estate to vehicles.[113]

In Japan, the total distance travelled by ordinary private cars in 2019, the most recent pre-Covid year, was 9.8% less than in 2010. This could be due to the increased utility of public transport, however the statistics indicate a decreasing need for driving private cars.[114]

Although many studies predict that new car sales are ebbing away in regions such as Europe and Japan, in the next 15 years the market is still expected to grow in regions such as China and South East Asia (see Figure 24).[115] In these regions, car ownership is a demonstration of social status, and remains a major driver of economic growth.

Figure 24.

Figures represent total forecasted market volume.
(Individual segments such as premium segment behave differently.)



Numbers may not equal total shown due to rounding.

Figure 24.

Total vehicle sales in China, the US, Europe, and Japan (Source: Deloitte)[115]

As part of their Covid-19 stimulus measures, governments spent $14 billion to support electric car sales, up by 25% from 2019, mostly due to stronger incentives in Europe.[79] Many of them provide heavy subsidies to purchase EVs (see Figure 25).[116] For example, the UK government offers a $3,480 discount on new EVs under $48,670; in California, the government offers electric car incentives of up to $7,000 on new EVs;[117] and Japan offers up to $19,000 for the purchase of a FCEV, and $3,800 for a BEV. Governments should avoid incentivizing the overconsumption of cars, especially if they are SUVs, even if they are electric.

Figure 25.

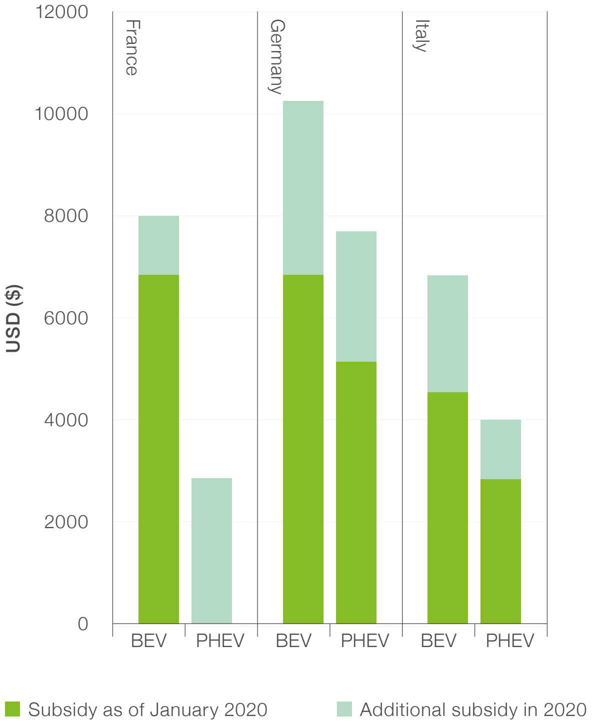


Figure 25.

National subsidies for EV purchase before and after economic stimulus measures in 2020 (Source: IEA)[116]

Shifting to a new kind of technology is not a silver bullet. We should be aware that the transition to EVs could easily become a tremendous wasted opportunity, if company profits from the overproduction and overconsumption of EVs are allowed to take priority over meeting the crucial targets for reducing GHGs. **The availability of 'clean' EVs could even be an incentive for guilt free overconsumption and we could end up creating a new source of carbon emissions even without the gasoline in the tank.**

The recent IPCC report confirmed that the global surface temperature has warmed strongly, and the rates of sea-level rise and ice loss have accelerated. Warming will continue until carbon emissions reach Net Zero. We must do everything faster and bolder, at all levels, leaving no sector behind.

Although EVs seem to be one of the most promising eco-friendly technologies, ultimately, the true zero-carbon mobility future should involve far less private cars, more efficient public transport systems, more car sharing options, the redesign of cities to make space for walking and cycling, and maybe even less travel. Automakers will need to rethink their business model which at the moment is set on profiting from selling more cars at an ever faster pace, while governments need to devise better economic strategies to drive the world to a livable future.

Appendix 1: Glossary

A	Al	Aluminium
B	BEV	Battery electric vehicle
	BF	Blast furnace
	BOF	Basic oxygen furnace
C	CAFE standards	Corporate Average Fuel Economy standards
	CAGR	Compound annual growth rate
	CCC	Climate Change Committee
	Co	Cobalt
D	DRC	Democratic Republic of Congo
	DRI	Direct reduced iron
	DSM	Deep sea mining
E	EAF	Electric arc furnace
	EoL	End-of-life
	ESP	Electronic Stability Programme
	EU	European Union
	EV	Electric vehicle
F	FCEV	Fuel cell electric vehicle
G	GHG	Greenhouse gas
H	HEV	Hybrid electric vehicle
I	ICCT	International Council on Clean Transportation
	ICE	Internal combustion engine
	IEA	International Energy Agency
	IPCC	Intergovernmental Panel on Climate Change
	IRMA	Initiative for Responsible Mining Assurance
J	JAMA	Japan Automobile Manufacturers Association
L	LDV	Light-duty vehicle
	LFP	Lithium iron phosphate
	Li	Lithium
M	MPV	Multi-purpose vehicle
N	NCA	Nickel cobalt aluminium
	NCM	Nickel cobalt manganese
	NHTSA	National Highway Traffic Safety Administration
	Ni	Nickel
P	PHEV	Plug-in hybrid electric vehicle
	PV	Photovoltaic
S	SBTi	Science Based Targets Initiative
	SMR	Steam methane reforming
T	T&E	Transport & Environment
U	UAW	United Auto Workers union / The International Union, United Automobile, Aerospace and Agricultural Implement Workers of America
	US	United States
W	WGS	Water gas shift

Definitions

BEV	vehicle without fuel tank or exhaust pipe and relying only on electricity for propulsion, a kind of non-ICE vehicle
CAFE standards	standards set by NHTSA for cars and trucks
EV	vehicle fully or partially powered by electricity
FCEV	electric vehicle using a fuel cell, a kind of non-ICE vehicle
HEV	vehicle with a small battery assisting the engine, a kind of ICE vehicle
PHEV	vehicle powered by both gasoline and electricity, a kind of ICE vehicle
SBTi	set up by a global team of people from organizations, such as CDP, the UN Global Compact, WRI and WWF. The SBTi sets requirements for participation in reducing emissions in line with climate science

Appendix 2: Company profiles

Company profile: Daimler

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F-	3.13	2.30	+	–

Overall, Daimler has been slow in transitioning to all-electric vehicles. Its sales of BEV/FCEVs and their percentage of all vehicle sales are low compared to more than half of the companies in this evaluation. In terms of GHG intensity, its Scope 1 and Scope 2 GHG intensity is significantly higher than most companies. While Daimler's efforts in reusing retired batteries is acknowledged, the company's involvement in the Dieselgate affair has caused negative impacts on the environment and further pushes down its score, which was already low.

Daimler AG (Daimler) is a German automotive company based in Stuttgart, best known for its flagship brand, Mercedes-Benz, for high-end luxury passenger cars.

Although initially hesitant to commit to electrification, stating in 2018 that it estimated a quarter of its fleet would be electric by 2025,[118] and later that it didn't want to "prematurely" rule out ICE vehicles,[119] Daimler announced in July 2021 that all newly launched architectures by Mercedes-Benz will be electric-only from 2025 onwards.[120] However, the company did not mention any timeline when ICE vehicles will be completely phased out.

Daimler has released plans on its intention to reduce the amount of materials required in each unit and increase the share of secondary raw materials, but the specific targets only apply to Mercedes-Benz.[121] Daimler has built a relatively significant capacity of energy storage system to reuse retired batteries.

Mercedes-Benz was one of the auto companies to back Trump's auto emissions rollbacks, but dropped out and reached a compromise deal with California on the state's standards in 2019.[122]

Further details on the score for Daimler

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Daimler sold approximately 2.5 million vehicles in 2020, of which only 1.86% were electric. This represents a sixfold increase compared with 2015, when only 0.3% of vehicles sold were electric.	3
Performance over the past five years Since 2015 the proportion of BEVs amongst Daimler's sales has risen, albeit very slowly. With overall sales of vehicles remaining relatively steady, the percentage of total sales and absolute number of units sold has increased year-on-year, from 7,066 units sold in 2016 to 46,978 units in 2020, at a compound annual growth rate (proportion of BEV/FCEVs) of 60.79%.	5
Global ICE phase-out plan Daimler has no global ICE phase-out plan. It only plans to have all new Mercedes-Benz architectures to be electric-only from 2025 onwards. And the Mercedes-Benz brand is ready to go "all electric at the end of the decade, where market conditions allow,"[120] implying that the brand may still sell gas-powered vehicles after 2030 in countries that lack consumer demand for EVs.[123]	1

Supply chain decarbonisation	Scores
Scope 1 and Scope 2 GHG intensity in 2020 In 2020, Daimler's global Scope 1 and Scope 2 emissions were 2.52 million metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 1.0 tCO_2-eq/veh, which is significantly higher than most companies.	1
Disclosure and upstream suppliers' GHG intensity in 2020 In 2020, Daimler partially disclosed the information for Scope 3 GHG emissions as well as GHG emissions from its upstream suppliers. However, only data for Mercedes-Benz is available. Including sub-suppliers, Daimler has some 60,000 suppliers within its supply chain, all of which are expected to adhere to Daimler's Supplier Sustainability Standards.[121] Whilst Daimler does periodically request disclosure, and conducts investigations in order to ensure compliance, the Standards does not contain any provisions with regards to resource sustainability or decarbonisation practices.[124]	3
Carbon reduction plan Although Daimler aims for carbon neutrality by 2039,[125] it does not have a validated SBTi target as a group. Its subsidiary, Mercedes-Benz, commits to SBTi 1.5°C target to reduce absolute Scope 1 and 2 GHG emissions 50% by 2030 from a 2018 base year. Mercedes-Benz commits to reduce Scope 3 GHG emissions from use of sold products 42% per vehicle kilometer by 2030 from a 2018 base year.[126]	3
Resource sustainability	
Raw materials reduction target N/A	+
Secondary materials usage target Mercedes-Benz, a subsidiary of Daimler, has released plans to reduce the amount of materials required for each unit, notably aiming for an increase in the share of secondary raw materials to 40%, which is set to be achieved by 2030.	
Battery reuse and recycle capacity Compared to its performance on the recycling of raw materials from batteries, Daimler has outperformed other companies on battery reuse. Daimler is currently operating a 12.8 MWh second-life battery storage plant that opened in Lünen and a 17.4 MWh replacement part storage facility in Hanover. With over 30 MWh storage capacity in total, Daimler has built the most capacity in battery reuse among the ten companies.[60] Daimler's performance on resource sustainability is acknowledged with a raise of half a grade to Daimler's overall score.	
Deductions	
In 2020, the US District Court for the District of Columbia and Daimler reached a settlement which required the company to recall and repair the emissions systems in Mercedes-Benz diesel vehicles sold in the US between 2009 and 2016, and pay $875 million in civil penalties and roughly $70.3 million in other penalties. The settlement addresses allegations that from 2009 to 2016, Daimler manufactured, imported, and sold more than 250,000 diesel Sprinter vans and passenger cars with devices programmed into the vehicles' complex emissions control software. These devices cause the vehicles to produce compliant results during emissions testing. But when not running a test, the vehicles' emissions controls perform differently, and less effectively, resulting in an increase in NOx emissions above compliant levels.[127] In 2021, a German consumer group filed a class action lawsuit against Daimler with a similar allegation.[128]	–
Daimler, BMW, Volkswagen (including Volkswagen brand, Audi and Porsche) possessed the technology to reduce harmful emissions beyond what was legally required under EU emission standards. But they avoided competing on using this technology's full potential to clean better than what is required by law.[129]	

Company profile: Ford

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F-	1.13	5.30	/	/

Ford has the lowest sales of BEV/FCEVs and the lowest as a percentage of all vehicle sales. It also lacks any plan to phase out ICE vehicles. In terms of GHG intensity and its carbon reduction plan, Ford does relatively well. In terms of resource sustainability, although the company was the first American auto-maker to sign onto the Initiative for Responsible Mining Assurance (IRMA), it has not made a public statement about deep sea mining.

Ford Motor Company (Ford) is an American multinational automobile manufacturer founded in 1903. North America and Europe are the two largest markets for Ford.

Ford was one of the early adopters of hybrid technology and offered its first hybrid model, Escape Hybrid in 2004. Ford has continued to make a small volume of hybrid and EV models with annual sales in the low thousands. Ford is a relatively minor player in Europe, with 5% of the passenger car market, and has struggled for years with the EU's increasingly strict emission standards.[130]

Until now, Ford has been focusing on hybrid models and only began to sell all-electric models in volume starting late 2020, lagging far behind in the EV competition. Even though it is attempting to catch up with its plans to offer several new BEV models in the coming years, it has not yet committed to a clear global ICE phase-out date. In August 2021, Ford, General Motors, and Stellantis jointly announced that they shared an aspiration to achieve sales of 40-50% of annual US volumes of electric vehicles (battery electric, fuel cell and plug-in hybrid vehicles) by 2030.[47]

The company has a history of regressive lobbying against US emission standards. Starting in 2019 Ford began to diverge from other players in the industry, such as General Motors and Toyota, and reached a compromise deal with California on the state's standards. The company generally became more positive about the prospect of regulating the transport sector after this point. However, Ford retains its membership of some regressive trade associations, many of which have been key in opposing climate regulation in the US and EU.[131]

Further details on the score for Ford

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Ford sold the least BEV/FCEVs in 2020, falling behind the other automobile rivals with sales of just 491 units. These small sales of BEVs are in the context of its huge global vehicle total sales, with the former making up for only 0.01% of the latter. As a result, Ford has become a laggard in the competition to provide sustainable options for its consumers.	1
Performance over the past five years The cumulative sales of Ford BEVs are just 3984 in the past five years and the CAGR for the proportion of BEVs and FCEVs is -5.58%, the only negative CAGR in all automakers.	0.5
Global ICE phase-out plan Ford does not have a global ICE phase-out date. In May 2021, Ford announced that it expected 40% of Ford's global vehicle volume to be fully electric by 2030.[132] However, the expectation still lacks ambition.	2
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 Ford disclosed its GHG emissions for Scope 1 and Scope 2 in 2020, with a record of 2.96 million metric tons of CO_2-eq in total. Its Scope 1 and Scope 2 GHG intensity is 0.7 tCO_2-eq/veh, which is pretty high.	4
Disclosure and upstream suppliers' GHG intensity in 2020 Since Ford did not disclose its Scope 3 GHG emissions, its average emission intensity for car production is unclear. However, its upstream suppliers' GHG emissions information is available, which is 39.7 million metric tons of CO_2-eq.	6
Carbon reduction plan Ford commits to a SBTi validated 1.5°C target. The company commits to reduce absolute Scope 1 and Scope 2 GHG emissions 76% by 2035 from a 2017 base year. It also commits to reduce Scope 3 use of sold products GHG emissions 50% per vehicle kilometer by 2035 from a 2019 base year.[126] Ford aspires to achieve carbon neutrality by 2040 and use 100% locally sourced renewable energy for all manufacturing plants globally by 2035.[133]	6
Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target N/A	
Battery reuse and recycle capacity Ford has signed a deal with Redwood Materials. The latter will receive battery packs that will be recycled, with the key elements then shipped back to Ford to be reused in future EVs. Although the company has committed to look at the battery value chain from mines to recycling, no holistic targets for battery recycling have been announced.[134] Additionally, Ford was the first American auto-maker to sign onto the IRMA. IRMA has since clarified that its standards cannot be used to assess or certify deep sea mining operations. While Ford has not made a public statement about deep sea mining, the company's approach to IRMA certification would appear to preclude sourcing metals from the deep sea.	

Company profile: General Motors

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
C-	6.69	5.60	/	–

Overall, General Motors sales of BEV/FCEVs and their percentage of all vehicle sales are the highest among all the companies. However, it should be noted that 58% of the sales come from a controversial mini EV sold in China. The company also has the most ambitious ICE phase-out date. These are the key factors that contribute to the relatively high grade. However, considering that it currently sells only one electric vehicle model in the US, and that sales of BEV/FCEVs are still only 3.15% of its global vehicle sales, General Motors needs to take more actions to show the world that its commitments are more than just words.

Founded in 1908, General Motors Company (General Motors) is one of the largest automotive companies in the world, headquartered in Detroit, US.

General Motors was an early pioneer of EV technology and manufactured the EV1 as early as 1996. It was introduced in response to a 1990 California law requiring carmakers to produce zero-emission vehicles in order to continue selling conventional automobiles in the state. General Motors produced 1,117 EV1s, but they were only made available for lease. It was popular among environmentalists. When the California regulation was watered down in 2001, General Motors didn't just stop making the cars; it recalled the vehicles and destroyed them, even though its drivers offered to buy them from General Motors. In 2002, General Motors released the notorious gas guzzler, the Hummer H2 SUV.

General Motors released its first global BEV the Chevrolet Bolt in 2016 but did not release any new global EV models between 2017 and 2020. In 2020, General Motors sold 26,552 Bolt EVs globally and 117,599 units of the low-cost (approximately $4,500) Hong Guang Mini EV which account for 58% of its BEV sales, exclusively in China.[135]

Concerns about the Hong Guang Mini EV

Even though Hong Guang Mini EV is only sold in China, the model's low cost has made it the second best selling EV in the world, just behind Tesla's Model 3. The vehicle's 2020 basic version comes without air-conditioning, with a top speed of 100km/h and starts at less than $4,500. Its safety specification which is below par also raised concerns. The vehicle was not equipped with airbags or Electronic Stability Programme (ESP). Under the regulations in the US, EU, Japan and India, it is illegal to sell cars without ESP; while in India and the US, it is illegal to have no airbags in the front seats.[xvii,136,137]

The very low cost might contribute to an overconsumption problem. In April 2021, the Shanghai government removed the eligibility of the Hong Guang Mini EV for a New Energy Vehicle license plate (a policy designed to fasttrack the purchase of EVs),[138] because it's overwhelming sales contributed to an excess of new cars that added burden to the city's traffic system.

In early 2021, General Motors announced that it aspired to eliminate tailpipe emissions from new light-duty vehicles by 2035. In August 2021, Ford, General Motors, and Stellantis jointly announced that they shared an aspiration to achieve sales of 40-50% of annual US volumes of electric vehicles (battery electric, fuel cell and plug-in hybrid vehicles) by 2030.[47] General Motors needs to take more actions to show the world that those are not just words.

xvii Only in 2021, its upgraded version installs airbags only at the driver seat, but still without ESP system.

Further details on the score for General Motors

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 General Motors sold a total of 218,626 BEVs in 2020, accounting for 3.15% of its global vehicle sales. Hong Guang Mini EV (only sold in China) accounts for 58% of BEV sales of General Motors.	6.5
Performance over the past five years To date, even though General Motors faces a decrease in global sales, its cumulative BEV sales continue to increase, reaching 406,394 units over the past five years, with a high compound annual growth rate for BEV proportion up to 203%. However, this fast growth in sales of BEVs is mainly occurring in the Chinese market (see above for concerns about the Hong Guang Mini EV model).	7.5
Global ICE phase-out plan General Motors announced that it "aspired" to eliminate tailpipe emissions from new light-duty vehicles by 2035.[46] General Motors' 2035 EV goal is ambitious, considering it currently sells just one electric vehicle model in the US, but a top executive has stated that "100% EV is a target, not a promise".[139] General Motors must show more practical actions to achieve the target.	6
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 General Motors discloses its annual GHG emissions and decarbonisation efforts in accordance with several reporting frameworks, including the CDP, the Global Reporting Initiative,[140] etc. In 2020, General Motors' global Scope 1 and Scope 2 emissions were 4.3 million metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 0.62 tCO_2-eq/veh.	4
Disclosure and upstream suppliers' GHG intensity in 2020 General Motors did not disclose its Scope 3 GHG emissions as well as upstream suppliers' GHG emissions in 2020. In 2019, General Motors' Scope 3 emissions were 249.38 million metric tons of CO_2-eq. Within Scope 3, its upstream suppliers' GHG emissions were 50.85 million tCO_2-eq, accounting for 20% of its total emissions. Its emission intensity during car production could be further reduced through sourcing renewable energy and applying low-carbon technologies.	6
Carbon reduction plan General Motors commits to a SBTi validated 1.5°C target. General Motors commits to reduce absolute Scope 1 and 2 GHG emissions 72% by 2035 from a 2018 base year*. General Motors commits to reduce Scope 3 GHG emissions from use of sold products of light duty vehicles 51% per vehicle kilometer by 2035 from a 2018 base year.	7

* The target boundary includes biogenic emissions and removals from bioenergy feedstocks.[126]

Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target N/A	
Battery reuse and recycle capacity In 2021, Ultium Cells LLC, a joint venture between General Motors and LG Energy Solution, collaborated with Li-Cycle to recycle up to 100% of the material scrap from battery cell manufacturing.[141] However, the recycling capacity of this cooperation is unclear. General Motors' sustainability report also mentions that data centres at Milford Proving Ground and the SAIC-GM-Wuling facility are re-using EV batteries. There is no evidence on the scale of these battery reuse facilities. Moreover, General Motors has yet to respond to questions about the company's intentions regarding metals sourced from deep sea mining.	

Deductions	
General Motors actively supported the Trump administration's drive to weaken fuel efficiency standards. Up to 2020, General Motors pushed President Trump to loosen standards on fuel economy and climate-warming emissions. General Motors only withdrew its support immediately after Trump had lost the election. General Motors' chief executive met with Mr. Trump in his first weeks in office and urged him to weaken the stringent tailpipe pollution standards.[142]	–

Company profile: Honda

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F+	3.50	1.70	+	/

Overall, Honda's sales of BEV/FCEVs and their percentage of all vehicle sales in the past five years are among the lowest. Although a late starter, its growth in the percentage of BEV/FEVs sold is the highest of all companies. Honda is the only Japan-based company to have a global ICE phase-out date even though it is not ambitious. With sales of BEV/FCEVs still only 0.35% of global vehicle sales, Honda needs to take much more aggressive actions in the transition to BEV/FCEVs to achieve the ICE phase-out target.

Honda Motor Company (Honda) is a Japan-based company that principally provides motorcycles, power products, automobiles and related parts. Although the compound annual growth rate for BEV/FCEV proportion has increased rapidly, at 251.44% over the past five years, global sales of BEV/FCEVs were only 15,620 in total in 2020. This is a small proportion (0.35%) of the large volume of global vehicle sales (4,461,653 units). When it comes to ICE phase-out plans, Honda has set a target to increase the ratio of BEV/FCEVs to 100% of global sales by 2040.[48] Honda once regarded hydrogen as the clean energy of the future. In 2021, Honda changed its hydrogen strategy and stated it would stop production of the Clarity fuel cell cars.[75] However, it is still unclear if the company has completely given up on hydrogen technology in passenger cars.

In terms of tackling emissions in the supply chain, Honda has established a system for the integrated management of data on the reduction of CO_2 emissions. All Scope 1, Scope 2 and Scope 3 GHG emissions for 2020 have been captured and reported.[143] However, evidence of Honda's work with suppliers to reduce emissions is not available.[144]

According to a research conducted by Greenpeace East Asia, Honda met CO_2 standards for cars in the US and EU from 2017 to 2019 but failed to meet standards in China from 2018 to 2020. Honda's average annual CO_2 performance is as high as 126 g/km in the EU and 119 g/km in the US between 2017 and 2019.[145] In Honda's Sustainability Report 2021, the company claims that it will achieve carbon neutrality for all of its products and corporate activities by 2050 through expanding its lineup of electrified products and use of hydrogen energy.[143] However, due to insufficient targets Honda was removed from SBTi.[57]

Honda was part of the group of auto companies to back Trump's auto emissions rollbacks, but dropped out and reached a compromise deal with California on the state's standards in 2019.[146]

Further details on the score for Honda

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Honda's total vehicle sales were 4,461,653 units in 2020, including 14,670 BEVs and 950 FCEVs. These two types of cars only account for 0.35% of global sales.	2
Performance over the past five years Over the past few years, there has been rapid growth in Honda's BEV/FCEV sales. The compound annual growth rate for BEV/FCEV proportion is therefore 251.44% for the past five years. Sales of FCEVs have been declining since 2019. However, cumulative sales of BEV/FCEVs were only 27,175 units between 2016 and 2020.	5
Global ICE phase-out plan Honda is aiming to increase its ratio of BEV/FCEVs to 100% of global sales by 2040. In order to achieve this goal, the company expects BEVs and FCEVs to account for 40% of its automobile sales in China and North America by 2030 (20% in Japan), 80% by 2035, and 100% by 2040 globally.[48]	5
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 In 2020, Honda's global Scope 1 and Scope 2 emissions were 4.5 million metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 1.01 tCO_2-eq/veh, which is the highest among all companies that have disclosed this information.	1
Disclosure and upstream suppliers' GHG intensity in 2020 Honda's Scope 3 emissions in 2020 are 249.98 million tCO_2-eq. However, information related to GHG emissions from its upstream suppliers, which are likely to be significant, and information to show in what ways and to what extent the company requires action on GHG emissions from its suppliers, was not available.	3
Carbon reduction plan Honda has shifted from its previous SBTi 2°C target to a 1.5°C target, and plans to achieve net zero CO_2 emissions throughout its products' life cycle and its corporate activities by 2050.[143] In addition, Honda Green Purchasing Guidelines and Honda Supplier Sustainability Guidelines set requirements for their suppliers.[143] However, Honda has failed to set a stringent climate target in time and as a result has been removed from the Science-Based Targets scheme.[57] It also lacks a carbon reduction plan with a detailed timeline and roadmap, although it has shifted from its previous 2°C target to a 1.5°C target.	1
Resource sustainability	
Raw materials reduction target N/A	+
Secondary materials usage target N/A	
Battery reuse and recycle capacity Honda signed an agreement with Battery Resourcers to recycle lithium-ion batteries this year. Batteries from Honda & Acura electric vehicles will initially be processed by the company's recently expanded site in Worcester, and a new commercial plant will be operational in the first quarter of 2022. The new site which will be capable of processing more than 20 million pounds of batteries. Compared to the other 9 companies, Honda has a relatively high battery recycling capacity. Therefore, Honda is given a half-grade raise to its overall score.[59]	

Company profile: Hyundai-Kia

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F+	4.81	3.10	/	–

Hyundai-Kia's numbers of BEV/FCEVs sold and their percentage of all vehicle sales are at the mid-range among all companies. Hyundai brand's ICE phase-out plan is only limited to four markets and has a late timeline. The company's score for supply chain decarbonisation is among the lowest because of its poor disclosure of Scope 3 emissions, while its carbon reduction targets are relatively weak and not specific enough compared with other companies.

Hyundai Motor Group (Hyundai-Kia to avoid confusion), is a South Korean chaebol[xviii] headquartered in Seoul, South Korea, mainly focused on manufacture and sales of automobiles. The group includes the Hyundai Motor Company (Hyundai), the Kia Corporation (Kia) and Genesis. Hyundai is an international auto manufacturing company founded in 1967 and is one of the largest members of the chaebol. The company took over Kia in 1998. Despite complex shareholding arrangements between affiliated companies, Hyundai is the de facto representative of the group. Given that Hyundai and Kia share technologies, vehicle platforms, and development strategies to a great extent, the two were considered together in this report, apart from their respective global ICE phase-out and carbon reduction plans, which are presented and evaluated separately, given their different commitments.

The number of Hyundai-Kia's BEV/FCEVs has continued to grow over the past five years, from 5,372 units to 132,529 units. The compound annual growth rate of BEV/FCEV proportion is 135.42%. However it only contributed to 2.16% of global vehicle sales. Both Hyundai and Kia launched their first dedicated BEV models, the Ioniq 5 and the EV 6 in 2021. While Hyundai-Kia has managed to sell a great volume of BEV/FCEVs, its global ICE phase-out plan is still falling behind. While it committed to launch a total of 44 eco-friendly vehicle models by 2025, these models include both HEVs and PHEVs.

According to research conducted by Greenpeace East Asia, Hyundai-Kia failed to meet the average corporate fuel consumption standards for passenger cars in China from 2018 to 2020 and violated CO_2 standards for cars in the US from 2017 to 2019.[145] In terms of decarbonising the supply chain, Hyundai-Kia has not yet made a commitment that is recognized by SBTi.

With ownership of Hyundai Steel, Hyundai-Kia should be more ambitious on the decarbonisation of its supply chain by committing to use green steel. Furthermore, the involvement of Hyundai-Kia's construction affiliate Hyundai E&C in building coal fired power plants has been criticized.[147]

xviii A chaebol is a "business association" and is a large, conglomerate family-controlled firm of South Korea characterized by strong ties with government agencies.

Further details on the score for Hyundai-Kia

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 The total sales of BEV/FCEVs for Hyundai-Kia were 132,529 units in 2020, accounting for 2.16% of its total vehicle sales in 2020. The increasing BEV sales were mainly driven by strong demand for its Kona electric sport utility vehicle, despite the coronavirus pandemic which has decimated demand for cars in most cases.[148]	4.5
Performance over the past five years Hyundai-Kia has been criticized for lagging behind its rivals in adopting emerging technologies, but it has been catching up fast with a significant increase in BEV/FCEV sales in the past five years. Its cumulative sales of BEV/FCEVs have risen to 277,696 units and its compound annual growth rate for BEV/FCEV proportion between 2016 to 2020 has reached 135.42%.	6
Global ICE phase-out plan Hyundai-Kia has no clear global ICE phase-out date. Hyundai aims to phase out all vehicles using fossil fuels in major markets such as the US, South Korea, Europe and China by 2040 while maintaining ICE vehicle production capacity in emerging markets including India, Russia and Brazil.[49] More specifically, BEV/FCEVs will account for 80% of its total fleet sales by then.[149] The two companies have different timetables with more detailed plans (see subsidiaries' plans below). It is clear that neither their plan to maintain ICE vehicle production nor their lack of a long-term commitment for BEV/FCEVs are consistent with the global goal for net-zero emissions. Genesis, a luxury brand that spun off from Hyundai committed to stop sales of ICE vehicles by 2030. However, Genesis only accounts for 2% of Hyundai-Kia's sales as of 2020.[150] Hyundai Hyundai aims to achieve 100% electrification (through BEV/FCEVs) in the European market by 2035, rising to 100% electrification in major markets by 2040.[151] Kia Kia has no plan to phase out ICE vehicles in any markets. Kia plans to build a full lineup of 11 BEVs (including passenger vehicles, SUVs and MPVs) by 2026 and increase volume of BEV sales to 0.88 million units by 2030. Kia plans to sell 1.6 million green cars which includes HEVs and PHEVs, which would account for 40% of sales by 2030.[152]	4

Supply chain decarbonisation	Scores
Scope 1 and Scope 2 GHG intensity in 2020 In 2020, Hyundai-Kia's global Scope 1 and Scope 2 emissions were approximately 3.61 million metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 0.59 tCO_2-eq/veh, which is relatively good compared to most of the other companies.	5
Disclosure and upstream suppliers' GHG intensity in 2020 Hyundai-Kia's Scope 3 emissions for 2020 were not available. According to self-reported data, Hyundai's Scope 3 emissions in 2020 were 93.88 million metric tons of CO_2-eq. Within Scope 3, its upstream suppliers' GHG emissions were 17.01 million tCO_2-eq. However, Kia has not disclosed its Scope 3 or upstream supplier GHG emissions. Therefore, the average emission intensity for Hyundai-Kia's car production is unclear.	3
Carbon reduction plan Neither Hyundai nor Kia commits to the SBTi target. Hyundai In September 2021, Hyundai committed to achieve carbon neutrality by 2045, including its global product lineup and all company operations.[149] Hyundai set a goal of reducing GHG emissions by 26% by 2030, compared to 2016.[153] The company has mentioned that it will pursue carbon neutrality, in line with the aim to limit global warming to well below 2, preferably to 1.5°C, by converting its products and business to focus on electric vehicles. Its targets are relatively weak and not specific compared with other companies. Kia Kia plans to reduce Scope 1 and 2 GHG emissions by 17.4% by 2025, from 2016 levels. A specific carbon reduction plan for its upstream suppliers has not been found.	1

Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target N/A	
Battery reuse and recycle capacity Hyundai has built a second-life EV batteries-based energy storage system at its Ulsan plant with a total capacity of 2 MWh. In 2020, Hyundai also built a 300 kWh energy storage system using second-life EV batteries in Gongju. Although the company has made some efforts on the reuse and recycling of batteries, the scale of these pilot projects is quite limited.[154]	

Deductions	
Hyundai-Kia, along with other companies, participated in lobbying activities to relax vehicle emission standards in the US. Hyundai-Kia maintained this position until 2021, after Trump's defeat in the presidential election.[68]	–
Hyundai-Kia has been criticised for its inconsistent environmental standards because its construction affiliate is building a coal-fired power plant in Vietnam.[147]	

Company profile: Nissan

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F+	3.31	5.40	+	–

Overall, Nissan's sales of BEV/FCEVs and their percentage of all vehicle sales in 2020 are at the mid-range among all companies, while its cumulative sales are among the best. While it was an early starter in the production of BEVs, the growth in the percentage of BEV/FCEV sales over the past five years has lagged behind its competitors. Nissan also fails to set an ambitious ICE phase-out plan. However, the company's score for its upstream suppliers emissions is particularly good. It is also the only company that has holistic targets for resource reduction and secondary material usage.

Nissan Motor Corporation (Nissan) is a Japan-based automobile company. As a leading player in the automotive sector, Nissan's global sales in 2020 were over 3.7 million units, 70,270 BEVs were sold in 2020. However, this only accounts for 1.87% of Nissan's global sales. The majority of BEV/FCEV sales are from the LEAF model, accounting for about 76.6%. The accumulated sales for the LEAF are 524,000 units since the launch of the first-generation model in 2010, as of March 31, 2021.[58]

In general, Nissan promised to take measures to meet the commitments of the Paris Agreement and increase efforts to reduce its GHG emissions. However, its response to climate change has not always been positive. In Europe, Nissan suggested weaker CO_2 light-duty vehicle targets.[155] In 2017, Nissan publicly challenged CO_2 standards in Australia so that existing models could still be circulated on the market.[156] In the US, Nissan supported Trump's legal battle with California and opposed the Obama-era fuel efficiency and emission standards. Not long after Biden's victory in the 2020 presidential election, Nissan withdrew from the litigation.[157]

Further details on the score for Nissan

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Nissan's total vehicle sales were 3,754,363 units in 2020, including 70,270 battery-electric vehicles (BEV). BEVs account for 1.87% of global sales.	3.5
Performance over the past five years Nissan BEVs account for less than 2% of global vehicle sales in recent years, with cumulative sales of 350,254 units between 2016 and 2020. The compound annual growth rate of BEV proportion is only 16.57% for the past five years.	4
Global ICE phase-out plan Nissan does not have a clear global ICE phase-out date. Nissan North America, has a target for more than 40% of its US vehicle sales to be fully electric by 2030, which is lagging behind the target set by Nissan in January 2021.[50]	1
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 In 2020, Nissan's global Scope 1 and Scope 2 emissions were 2.54 million metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 0.68 tCO_2-eq/veh.	4
Disclosure and upstream suppliers' GHG intensity in 2020 Nissan discloses its GHG emission information relatively comprehensively. Furthermore, Nissan's Scope 3 emissions in 2020 were 135.07 million metric tons of CO_2-eq. GHG emissions from upstream suppliers are 12.73 million metric tons of CO_2-eq, meaning 3.39 tCO_2-eq/veh in terms of emission intensity in car production.	8
Carbon reduction plan Nissan commits to the SBTi "Well-below 2°C" target to reduce absolute Scope 1 and 2 GHG emissions 30% by 2030 from a 2018 base year. Nissan also commits to reduce Scope 3 GHG emissions from use of sold products 32.5% per vehicle kilometer over the same time frame.[126] In the long run, Nissan plans to achieve carbon neutrality across the entire life cycle of its products (such as material extraction, manufacturing, vehicle use and vehicle recycling or reuse at end-of-life) by 2050.[58]	4
Resource sustainability	
Raw materials reduction target Nissan has a target to reduce new natural resource usage by 30% per vehicle by 2022.[58]	+
Secondary materials usage target Nissan will use materials that do not rely on newly mined resources for 70% of the materials used in each vehicle by 2050.[58] Among the ten companies, Nissan is the only company that has an ambitious target to reduce the consumption of raw materials with a clear timeline. Therefore, Nissan gets a '+' in the resource sustainability column in the score table, adding half a grade to its overall score.	
Battery reuse and recycle capacity N/A	
Deductions	
In 2019, Nissan North America along with other companies, participated in lobbying activities to relax vehicle emission standards in the US. Nissan maintained this position until Trump lost the presidential election.[157]	–

Company profile: Renault

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
D-	4.31	6.75	/	–

Renault scores the highest among all companies for its sales of BEV/FCEVs as a percentage of all vehicle sales in 2020. This is mainly achieved by sales of the Zoe BEV. Renault does not have an ICE phase-out date in any market. Its GHG emission disclosure and reduction results are relatively better than its competitors. However, the company is being prosecuted for its role in the Dieselgate scandal, which results in a deduction in its overall grade.

Renault Group (Renault) is a French multinational automobile manufacturer established in 1899. Although Renault, Nissan and Mitsubishi have formed an alliance to enhance their competitiveness and profitability, the strategic partnership between the three partner companies is not a merger or an acquisition. Therefore Renault is considered as an independent car manufacturer in this report.

With over 2.5 million units vehicles sold in more than 130 countries in 2020, Renault is among the top ten car manufacturers. Renault has actively embraced BEVs in recent years. The low-price Zoe model was the largest-selling BEV on the European market for many years. Although the sales of BEVs as a percentage of Renault's overall sales has continued to grow in the past five years, it only made up of 4.37% global sales in 2020. In addition, Renault's measures to decarbonise its supply chain have been relatively effective.

In September 2021, a media report quoted Renault's Executive Vice President for engineering, who stated that Renault would seek to weaken the EU's 2035 phase-out date for internal combustion engines, by delaying the date until 2040 for hybrids.[131]

Further details on the score for Renault

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Renault's total vehicle sales are 2,609,226 units in 2020, including 114,008 BEVs. BEVs account for 4.37% of global sales.	6.5
Performance over the past five years Renault has made some efforts in the adoption of BEVs in recent years. The proportion of BEVs has continued to grow in the past five years, from 0.81% in 2016 to 4.37% in 2020. The compound annual growth rate of BEV proportion is 52.19% for the past five years.	5
Global ICE phase-out plan Renault does not have a clear global ICE phase-out date. The company only announced plans to make 90% of its models battery electric by 2030 in Europe.[158]	0
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 In 2020, Renault's global Scope 1 and Scope 2 emissions were 950.1 thousand metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 0.36 tCO_2-eq/veh, which is better than most companies.	7
Disclosure and upstream suppliers' GHG intensity in 2020 In its climate report, Renault disclosed the carbon footprint of the whole life cycle to be 30.54 tCO_2-eq/veh, while 15.2% of it comes from upstream suppliers. Renault's upstream suppliers' GHG emission intensity is 4.64 tCO_2-eq/veh.[159]	8
Carbon reduction plan Renault has committed to achieve carbon neutrality in Europe by 2040 and worldwide by 2050.[159] The company has obtained the validation of the SBTi for its "Well-below 2°C" climate targets. The manufacturer commits to reduce Scope 1 and 2 GHG emissions by 60% per car produced by 2030, from a 2012 base year and reduce Scope 3 GHG emissions from use of sold products by 41% per vehicle kilometer by 2030, from a 2010 base year.[126]	5
Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target N/A	
Battery reuse and recycle capacity Advanced Battery Storage is run by Renault to reuse the retired batteries from electric vehicles. At present, the Douai site has a total installed capacity of 4.7 MWh using second-life batteries, as well as new batteries stored for future after-sales use. A large E-STOR system using around 1000 second-life batteries to store 14.5 MWh of energy will also be installed soon.[160] However, considering the sales volume of Renault, these are not sufficient for additional raise of score.	
Deductions	
In 2021, A French court had charged Renault with deception over a diesel emissions probe. Fraud investigators accused Renault of "fraudulent strategies" used by top managers for over 25 years to falsify the emission test results. According to a fraud squad report seen by AFP, investigators found discrepancies of up to 377% between emissions from models during tests, and results from actual on-the-road use by consumers.[161]	–

Company profile: Stellantis

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F--	2.88	3.05	/	–

The sales of BEV/FCEVs and their percentage of all vehicle sales by either FCA or PSA are not impressive, although the percentage for both companies grew modestly in the last five years. Apart from Fiat, none of the Stellantis brands have any ICE phase-out targets. As a newly formed automobile giant, Stellantis needs to show society it is a socially responsible corporation committed to fighting the climate crisis.

Stellantis N.V. (Stellantis) is a multinational automotive company formed in January 2021 by the 50/50 merger of Fiat Chrysler Automobiles (FCA) and Peugeot S.A. (PSA). After a proposed merger of FCA and Renault fell apart in mid-2019 due to pressures from the French government and Nissan,[162] FCA and PSA agreed a merger to create Stellantis. Given that the majority of data used in this report refers to performance and actions that occurred before the merger, FCA and PSA have been evaluated separately. But the findings for both of these are discussed together, in order to show the new Stellantis a better pathway towards decarbonisation in the future. The final score of Stellantis is the average of the assessment for both FCA and PSA.

In July 2021, Stellantis gave its first public statement on its electrification strategy, saying that it would be investing approximately $35 billion through 2025 developing low emission vehicles, with the goal of increasing its sales of low-emissions vehicles to 70% of European sales and 40% of US sales by 2030.[163] However, this plan is unambitious because the so-called “low emission vehicles” is likely to include hybrid vehicles. In August 2021, Ford, General Motors, and Stellantis jointly announced that they shared an aspiration to achieve sales of 40-50% of annual US volumes of electric vehicles (battery electric, fuel cell and plug-in hybrid vehicles) by 2030.[47]

Citroën (now part of Stellantis) had been charged with consumer fraud by French prosecutors in a far-reaching diesel emissions probe. It would have to make a deposit of about $ 9.3 million and provide a bank guarantee of $29 million for potential compensation for losses. Peugeot (now part of Stellantis) has also been charged in France over the dieselgate investigation. Citroën and Peugeot are facing prosecution in France over the Dieselgate emissions cheating scandal.[164]

Further details on the score for Stellantis

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 FCA FCA sold approximately 3.6 million vehicles in 2020, of which 5,470 (0.15%) were electric. This is an increase from 2019 when 0.04% of the 4.4 million units solid were electric.	1.5
PSA In 2020 PSA sold approximately 2.5 million vehicles, of which 67,446 were electric, accounting for 2.71% of total sales. This is a significant increase on 2019 figures where BEV/FCEVs accounted for just 0.2% of the nearly 3.4 million units sold.	4.5
Performance over the past five years FCA Since 2016, the number of BEVs sold has not changed in any meaningful way, rising from 0.08% of total sales in 2016 to 0.15% in 2020. However this increase in percentage is largely a function of a reduction in overall sales, rather than an increase in BEV sales; the absolute numbers of BEVs sold have only risen from 3,897 (2016) to 5,470 (2020). Cumulative BEV sales for the past five years were only 16,959 units with a low compound annual growth rate of 15.38%.	2
PSA By contrast, PSA has significantly increased its volume of BEV sales, although this has been a very recent phenomenon. From 2016 to 2019, sales of BEVs were between 0.16% to 0.2% of total sales, rising tenfold in 2020 to 2.71% of sales, with the number of units sold increasing from 6,855 (2019) to 67,446 (2020).	5
Global ICE phase-out plan FCA Within the FCA group, although Fiat announced in 2021 that, its product line-up will gradually become electric-only between 2025 and 2030,[165] no other FCA brands have announced an ICE phase-out date. It is too limited to secure a score in this aspect for Stellantis.	0
PSA Among the brands under the PSA umbrella, only Peugeot has announced that it planned to have a 100% electrified range and no longer offer pure petrol or diesel as new cars from 2023. However, it does not specify what level of electrification it is aiming for and it is likely to include hybrid vehicles.[166,167]	0

Supply chain decarbonisation	Scores
Scope 1 and Scope 2 GHG intensity in 2020 FCA In 2020, FCA's global Scope 1 and Scope 2 emissions were 2.91 million metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 0.8 tCO_2-eq/veh, which is unsatisfactory.	2
PSA In 2020, PSA's global Scope 1 and Scope 2 emissions were 887 thousand metric tons of CO_2-eq. Its Scope 1 and Scope 2 GHG intensity is 0.36 tCO_2-eq/veh, which is better than most companies.	7
Disclosure and upstream suppliers' GHG intensity in 2020 FCA According to FCA's own estimation with the data disclosed by 231 suppliers which accounted for approximately 65% of FCA annual purchases, its upstream suppliers' GHG emissions are 7.9 million metric tons of CO_2-eq.[168]	3
PSA PSA did not disclose its Scope 3 emissions in 2020 or its upstream suppliers' GHG emissions. Although not a universal requirement for suppliers, PSA collects status reports from suppliers on their decarbonisation plans. PSA further details that its environmental goals are included in contracts with suppliers, specifically around the types of materials used and CO_2 generated. However many if not most of these goals are framed as targets and are not absolute requirements for suppliers.[169]	0
Carbon reduction plan FCA Whilst FCA provides information on its performance to date, there is little information on FCA's future plans, particularly with regards to quantifiable decarbonisation targets.	0
PSA PSA has a SBTi-approved decarbonisation plan of 2°C.[126] PSA has identified that its Scope 1 and 2 emissions can be reduced via energy management, site compression and building isolation, use/production of renewable energies, technical innovation, and compensation of residual emissions.[169]	4
Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target N/A	
Battery reuse and recycle capacity FCA FCA announced that it is cooperating with the US Advanced Battery Consortium on the recycling of lithium-ion batteries to produce new cathode materials. However, there are no details on the capacity and the timeline of the project. PSA N/A	
Deductions	
FCA In 2019, FCA sided with the Trump administration in a lawsuit to weaken California's fuel economy standards, and continued its support until 2021.[170] FCA's parent Stellantis only dropped out of the lawsuit after Trump's defeat in the presidential election.[67]	–
In 2020, FCA was fined a approximately $10.2 million civil penalty in the US to settle allegations that it misled investors by not disclosing that it conducted only a limited internal review of its compliance with emissions regulations.[171]	

Company profile: Toyota

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
F--	1.88	4.45	/	–

Toyota's sales of BEV/FCEVs only account for 0.12% of its 2020 global sales, among the lowest in this evaluation. The compound annual growth rate of BEV/FCEV proportion is just 54.74% over the last five years. Even though Toyota claims that it will achieve net-zero by 2050, it has no intention of phasing out ICE vehicles and its reliance on fossil fuel. Not only does the company lack ICE phase-out targets, it has become the industry's biggest obstacle to the all-out transition to electric vehicles. Toyota is among the most vocal industry players advocating for ICE vehicles, including hybrids, and even its investors have put pressure on the company to stop its negative anti-climate lobbying activities.

Toyota Motor Corporation (Toyota) is a Japan-based company mainly engaged in the design, manufacture and sale of automobiles, with over 8.8 million vehicles delivered around the world in 2020, selling cars in 204 countries and regions around the world.[172] As the maker of the world's first mass-produced hybrid car, the Prius made Toyota the pioneer in eco-friendly cars for many years. However, the auto giant has continued to invest more heavily in hybrids despite the global trend in recent years towards fully electric vehicles with lower GHG emissions.

According to research conducted by Greenpeace East Asia, Toyota met CO_2 emission standards for passenger cars in the US from 2017 to 2019 and those in the EU from 2016 to 2019, after receiving heavy fines for violation of the Clean Air Act from 2005 to 2015.[173] However, the company failed to meet corporate average fuel consumption standards for passenger cars in China from 2016 to 2020. Its sub-manufacturer FAW Toyota (Sichuan) exceeded standards for five years consecutively in China. The CO_2 emissions reductions made by Toyota's joint ventures have averaged at 18% (annual reduction rate of 3.6%) from 2016 to 2020 in China.[145]

Toyota is among the most vocal industry players advocating for ICE vehicles, and even its investors have put pressure on the company to stop its negative anti-climate lobbying activities.[5] Although it announced its Global Environmental Challenge 2050, Toyota takes a cautious and conservative stance on the phase-out of ICE vehicles and has failed to embrace BEV/FCEVs.[174,175] Toyota lobbied heavily against a rapid transition to BEV/FCEV fleets, deliberately slowing down global electrification efforts. Top leaders at Toyota have publicly criticized what they described as excessive hype over BEVs in many cases.[174,176,177] With a goal of reducing CO_2 emissions by 25% by 2030 throughout the entire vehicle life cycle compared to 2013 levels, Toyota needs to set a far more ambitious emissions reduction target in order to step up its efforts to decarbonise the supply chain and its entire fleet.

Over-reliant on its existing hybrid expertise, Toyota has become the industry's biggest obstacle to the all-out transition to electric vehicles.[63] Until now, Toyota has been slow to invest in transitioning to all-electric. In 2020, Toyota decided to stop investing in building battery electric cars in the UK until after 2027.[178] This would mean that the first Toyota BEV would not be built in the UK until 2034 at the earliest. To date, many measures have been taken to extend the role of hybrid technologies.

Toyota also fought to change the rules of the game. The company actively lobbied for weak fuel economy standards and opposed policies to ban gasoline and diesel vehicles in Australia, India, and the UK.[179,180,181,182,183] In 2019, Toyota, cooperating with other major automakers, sided with former President Donald Trump in his attempt to revoke California's authority to set its own auto tailpipe emission standards and advocated for more flexibility of auto standards to "meet consumer needs".[170] It only abandoned its efforts in 2021 after Trump was no longer the president.[170] These lobbying activities have delayed the strategy for electrification and climate change mitigation around the world.

Further details on the score for Toyota

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Toyota's total vehicle sales are 8,847,303 units in 2020, including 9,154 BEVs and 1,564 FCEVs. These two types of cars only account for 0.12% of global sales.	2
Performance over the past five years It did not sell any BEVs in any major market outside China until early 2020.[184] Sales of FCEVs have also shown a general downward trend in recent years. The cumulative sales of BEVs and FCEVs were only 23,316 units from 2016 to 2020. The proportion of these two types of cars has never exceeded 0.2% of annual sales.[185] The compound annual growth rate of BEV/FCEV proportion is 54.74% in the past five years.	3.5
Global ICE phase-out plan Toyota has not defined a phase-out target or committed to eliminating ICE vehicles by a specified date. Toyota's plans for the US market are for all-electric or fuel-cell-powered vehicles to make up only 15% of total sales by 2030.[186]	0
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 Toyota has not yet disclosed information on its GHG emissions for 2020. As an alternative, self-reported emissions data for 2019 was used for the score. In 2019, Toyota's global Scope 1 and Scope 2 emissions were 5.68 million metric tons of CO_2-eq, its Scope 1 and Scope 2 GHG intensity is therefore 0.56 tCO_2-eq/veh.	5
Disclosure and upstream suppliers' GHG intensity in 2020 In 2019, Toyota's global Scope 3 emissions were 397.94 million metric tons of CO2-eq. Within Scope 3, its upstream suppliers' GHG emissions were 65.1 million tCO_2-eq. However, Scope 3 and upstream suppliers' GHG emissions for 2020 were not available.	6
Carbon reduction plan Toyota does not commit to the SBTi target. The company claims that it will reach net-zero carbon emissions among its Group factories by 2035.[187] Although numerical targets have been set, they are not ambitious. To date, Toyota has not communicated any long-term goals to its auto parts partners who procure parts and materials from the secondary and tertiary manufacturers.[188]	2
Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target N/A	
Battery reuse and recycle capacity Toyota has opened a battery life cycle management plant for batteries of hybrid cars sold in Thailand. Opening in 2019, the plant has the capacity to diagnose 10,000 hybrid vehicle batteries and recycle 20,000 per year.[189] Regarding battery reuse, Toyota has cooperated with Chubu Electric Power to run a battery storage system with a capacity of approximately 10,000 kW in FY 2020.[190] Indeed, Toyota has put efforts on battery recycling and reuse, however, considering the annual sales of the company, they are not significant enough for an additional raise to the overall grade.	

Deductions	
In 2021, a settlement was reached between regulators of the US and Toyota. Toyota had delayed filing hundreds of mandatory reports related to emission-related defects and recalls from 2005-2015, in violation of the Clean Air Act. This could lead to the delay or avoidance of emission-related recalls, resulting in excess emissions of air pollutants caused by the defects. Under the terms of the settlement, Toyota will take steps to ensure compliance and pay a civil penalty of $180 million.[191]	–
In 2020, Norway banned Toyota's misleading advertising campaigns that portrayed hybrids as "self-charging vehicles" with an "infinite range".[192]	
Toyota's chairman Akio Toyoda has been vocal in support of a delay to the phase-out of ICE vehicles worldwide. He chairs the Japan Automobile Manufacturers Association (JAMA) which has been lobbying for Japan to continue selling cars with internal combustion engines. As of 2021, the association and Toyota not only show no intention of ending their reliance on fossil fuels, they are maintaining that eliminating ICE vehicles is not the goal, against the global wave of electric vehicles.[65,193]	
Toyota sided with the Trump administration in a lawsuit to weaken California's fuel economy standards, and continued its support until 2021.[170] Toyota only dropped out of the lawsuit after Trump's defeat in the presidential election.[67]	

Company profile: Volkswagen

Overall grade	Phase-out of ICE vehicles full marks: 10, weight: 80%	Supply chain decarbonisation full marks: 10, weight: 20%	Resource sustainability	Deductions
D	5.19	4.35	/	–

Volkswagen's 2020 sales of BEV/FCEVs are relatively high among the companies as a whole. However, it does not have an official ICE phase-out date for any market or any intention to set one. Its disclosure of GHG emissions and performance in reducing these are at the mid-range among its competitors. The company's decarbonisation commitment is still a long way from being compatible with the 1.5°C trajectory. It has also been heavily engaged in lobbying activities to weaken and delay environmental regulations.

Volkswagen Group (Volkswagen), based in Wolfsburg, Germany, is one of the largest automotive manufacturers in the world. In 2016 and 2017 Volkswagen was the global market leader, and typically 40% of Volkswagen's sales come from the Chinese market.[194]

In September 2015, it came to light that Volkswagen had been intentionally installing "defeat devices" on diesel engines since 2009. These devices lowered emissions of NOx during laboratory testing, allowing vehicles to meet US EPA (and other national) emission standards.[195] This disguised the fact that real-world emissions were approximately 40 times greater than claimed for nearly 11 million cars globally,[196] resulting in over $37.8 billion of costs, much of it for fines, buybacks and compensation payouts in the US.[197]

According to a Greenpeace East Asia analysis, Volkswagen did not meet CO_2 standards for cars[xix] in the US from 2017 to 2019. During this period, Volkswagen's average annual CO_2 emissions were 145 g/km, with an average of 14 g/km higher than the CO_2 standards in the US. In Europe, Volkswagen increased its average CO_2 emissions by 3% from 2016 to 2019. In addition, real world CO_2 emissions did not meet China's standards in 2019 and 2020.[145]

In 2018, the company set a goal to offer more than 30 SUV models throughout the world and correspondingly increased its SUV share in its global sales to 50% by 2025 regardless of the higher material and fuel consumption of SUVs.[198]

Volkswagen was part of the group of auto companies which backed Trump's auto emissions rollbacks, but dropped out and reached a compromise deal with California on the state's standards in 2019.[146] The "Dieselgate" incident continues to plague Volkswagen, with the EU levelling antitrust fines against the group as recently as July 2021, for colluding on technical development in the area of nitrogen oxide cleaning.[129]

Following on from this, Volkswagen sought to recover from the incident by leaning fully into electric vehicles, with the stated goal of launching 70 all-electric models across the group by 2030.[199] In Europe, Volkswagen is selling its battery electric ID models as climate neutral. However, only 10% of the production emissions have actually been reduced by Volkswagen or its suppliers. The rest has been offset via a dubious compensation project in Indonesia.[200] After an investigative report from Greenpeace cast doubts that these offsets are backed up by actual emissions reductions, Volkswagen cut ties with the project.[201]

Further details on the score for Volkswagen

Performance on phase-out of ICE vehicles	Scores
Performance in 2020 Of the approximately 8.77 million vehicles sold by Volkswagen in 2020, only 212,959 were BEVs, accounting for just 2.43% of total sales. However, this is an almost threefold increase in sales from 2019, and a tenfold increase from 2018.	5.5
Performance over the past five years Volkswagen's annual total BEV sales have increased from 12,748 units in 2016 to 212,959 units in 2020, with a compound annual growth rate up to 108.45%. Despite the ambitious rhetoric, BEVs still ultimately make up a very small part of Volkswagen's sales.	6.5

xix In the US, car refers to the passenger automobiles (see definitions for passenger automobiles (cars) and non-passenger automobiles (trucks) in 49 CFR 523)

Performance on phase-out of ICE vehicles	Scores
Global ICE phase-out plan Volkswagen does not have a clear global ICE phase-out date. Audi promises to end ICE production with the exception of the Chinese market.[202] The Volkswagen brand said all-electric vehicles expected to exceed 70% of European and 50% of Chinese and US sales volumes by 2030.[53] One of its board members mentioned the Volkswagen brand plans to stop selling combustion engines cars in Europe by 2035.[203] There is no phase-out date for the other Volkswagen brands.	3
Supply chain decarbonisation	**Scores**
Scope 1 and Scope 2 GHG intensity in 2020 According to its self-reported emissions information, Volkswagen's global Scope 1 and Scope 2 emissions were 7.14 million metric tons of CO2-eq in 2020. Its Scope 1 and Scope 2 GHG intensity is 0.81 tCO_2-eq/veh, which is higher than most companies.	2
Disclosure and upstream suppliers' GHG intensity in 2020 In 2020, Volkswagen's global Scope 3 emissions were 369 million metric tons of CO2-eq. Its upstream emission intensity is 6.99 tCO_2-eq/veh, which is higher than other companies that have disclosed upstream GHG emissions information.	7
Carbon reduction plan Volkswagen commits to a SBTi validated "Well-below 2°C" target. Volkswagen commits to reduce absolute Scope 1 and 2 GHG emissions 30% by 2030 from a 2018 base year.[126] Its commitment is still far from 1.5°C compatible.	4
Resource sustainability	
Raw materials reduction target N/A	/
Secondary materials usage target In its 2020 Sustainability Report, Volkswagen speaks of the need to reduce the use of aluminium. The company describes "further clarifying targets and indicators and also realizing circular business models for the most important components and materials, such as battery, steel, aluminum or plastics" as central to implementing Volkswagen's circular economy strategy. But it is unclear exactly what this strategy looks like: instead of naming concrete goals and measurable indicators, only individual model projects and exemplary recycling processes are referred to.[204]	
Battery reuse and recycle capacity The Salzgitter plant which went into operation at the start of 2021 has been designed to recycle up to 3,600 battery systems per year during its pilot phase, which is the equivalent of approximately 1,500 metric tons of batteries. In addition, Audi has opened a battery storage unit in Berlin in 2019. The storage unit has a capacity of 1.9 MWh and uses end-of-life lithium-ion batteries from development vehicles to test various interaction scenarios between electric cars and the power grid. However, compared to the number of BEVs sold over the past five years, the scale of the pilot battery reuse system is relatively very small.[205]	
Deductions	
Daimler, BMW, Volkswagen (including Volkswagen brand, Audi and Porsche) possessed the technology to reduce harmful emissions beyond what was legally required under EU emission standards. But they avoided competing on using this technology's full potential to clean better than what is required by law. Volkswagen was fined for breaching the antitrust rule by the European Commission.[129]	–
It was reported that the company's lobbyist used a fear scenario at the EU Commission's advisory group video conference to lobby against the Euro 7 directive,[206] an emission regulation that could further reduce nitrogen oxide emissions and prevent premature deaths.[207]	

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