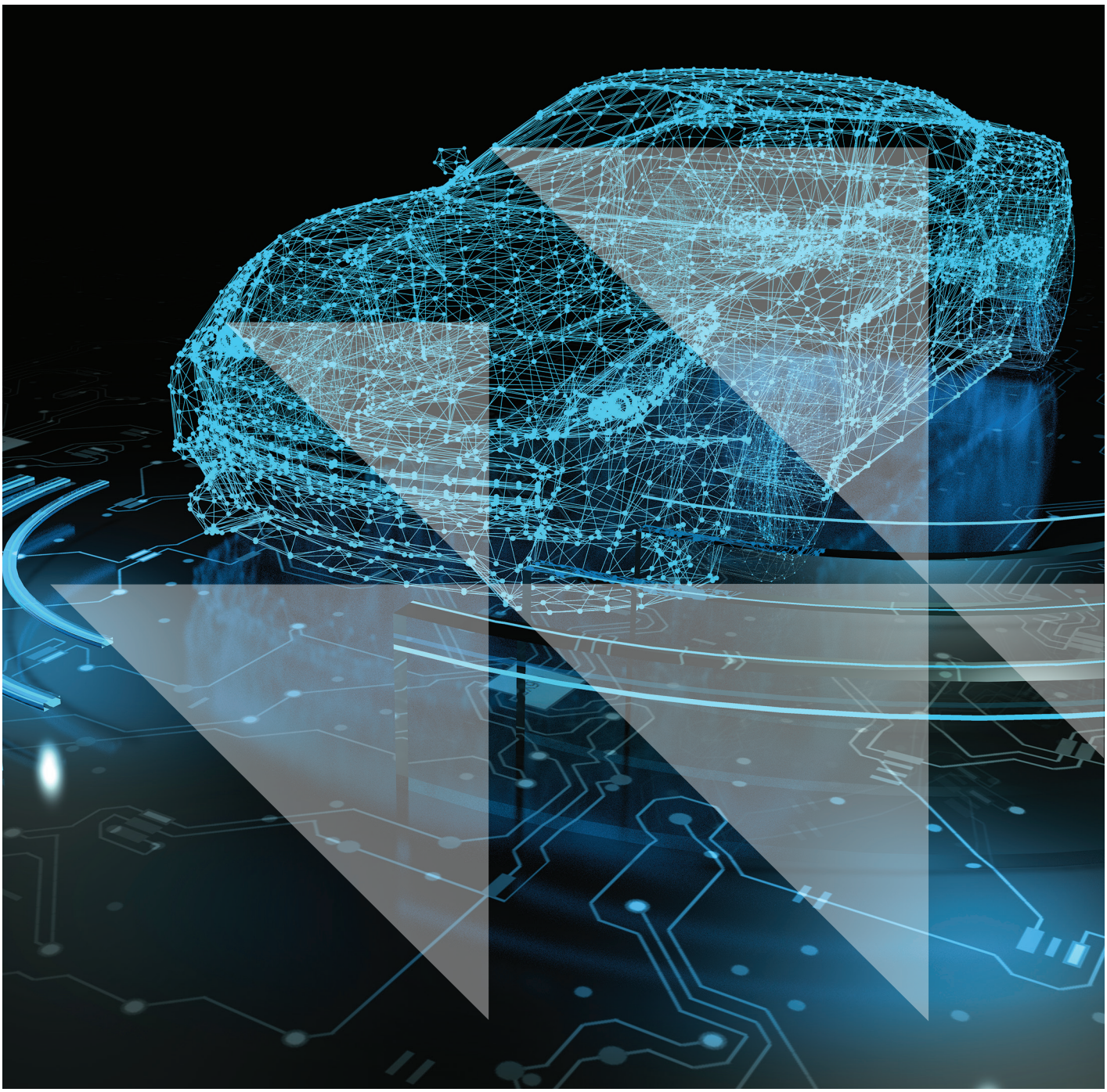
Driving disruption

Which automotive companies will seize the opportunities in a low-carbon economy?

January 2018



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Linking climate-related metrics to earnings for automotive companies

This report updates and expands CDP's research and League Table for the global automobile original equipment manufacturers (OEMs), first published in February 2015 and again in March 2016. It ranks 16 of the largest publicly listed automotive companies on business readiness for a low-carbon transition. The companies in aggregate represent 79% of the global passenger vehicle market by sales volume.

The automotive sector is reaching a tipping point; facing disruptive forces from advanced vehicles[1] and autonomous, shared driving. Tightening emissions regulations[2] and country quotas are forcing companies to increase penetration rates of low-emission vehicles. OEMs face challenges from tech players and profits are shifting towards tech / software suppliers and ride-sharing services.

Incumbent OEMs may see these challenges as threats to existing business models but to be successful they must embrace the new opportunities and markets that will become available over the coming years.

There are three key areas assessed in the League Table, which have been aligned with recommendations for company reporting from the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD):

Transition risks: We assess companies' fleet emissions performance and progress towards meeting emissions standards in the EU, US, China and Japan.[3] We also rank companies on manufacturing emissions and energy intensity performance and identify which OEMs may be more resilient to disruptive technologies and market risks.

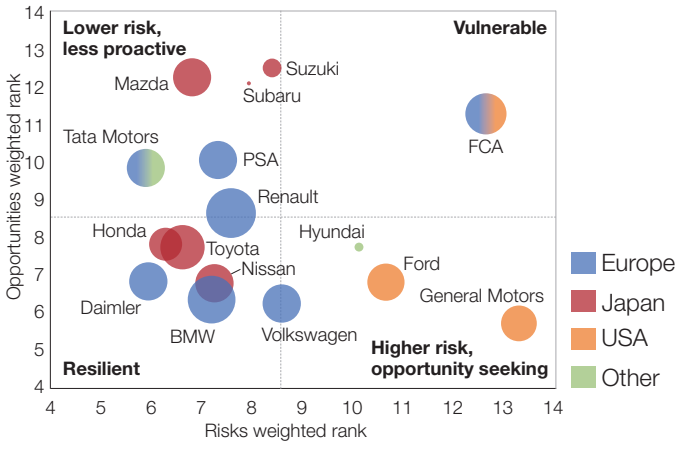
Transition opportunities: We assess companies' progress and strategy in the areas of advanced vehicles, autonomous driving vehicles (ADVs) and mobility as a service (MaaS), as well as R&D activity and renewable energy use.

Climate governance and strategy: We analyze companies' governance frameworks including emissions reduction targets, supplier engagement, water use and alignment of governance and remuneration structures with low-carbon objectives.

Key findings

- Highest ranked companies are **BMW, Daimler** and **Toyota.** Lowest ranked are **Suzuki, FCA** and **Subaru.**
- **Tata Motors** shows the most improvement, **Renault** has the largest fall in League Table rankings relative to 2016.
- 2017 saw a **profusion of OEM targets for low-emission and autonomous vehicles** – the most aggressive see fully autonomous (Level 4) self-driving services as early as 2019 and up to 25% of sales from battery electric vehicles (BEVs) by 2025.
- Since 2015 OEMs and technology companies have **invested more than $80 billion in companies developing MaaS and ADV** capabilities.[4]
- **China will play a pivotal role in auto sector disruption,** the largest vehicle market in the world has aggressive targets for new energy vehicles (NEVs).
- **Companies show some resilience to disruptive technologies** through exposure to emerging markets, luxury vehicles, high margins and diversification in areas such as trucks, motorbikes and machinery.
- **R&D % of sales is high compared to most sectors but lower than tech players entering the market.** In the face of this new competition, OEMs are beginning to focus more spend on disruptive tech, Japanese OEMs lead on advanced vehicle innovation and US OEMs on ADVs.
- **OEMs are at risk of missing fleet emissions targets:** average emissions reduction rate since 2010 of 2.9% p.a. compared to 5.3% p.a. required to avoid financial penalties.
- **OEMs will face tougher fleet emissions testing**[5] and with rising popularity of SUVs and diesel sales in decline, companies are forced to increase the share of advanced vehicles to meet targets and avoid paying regulatory fines.
- **Manufacturing efficiency is on an improving trend** – 15 of 16 companies have taken steps to reduce emissions and energy intensity of operations.

Figure 1: Opportunity vs. risk for low-carbon transition



Bubble size: Larger bubble size = stronger performance on climate governance & strategy
Source: CDP

1. Advanced vehicles includes vehicles such as fuel cell vehicles (FCVs), battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs).
2. Road transport accounts for 17% of global CO_2 emissions (of which 66% is from light road and 34% from heavy road transport), IEA ETP 2017.
3. In aggregate the EU, US, China and Japan account for 74% of passenger vehicle demand.
4. $11 billion directly attributable to the 16 companies in this report.
5. Many regions will be implementing the Worldwide Harmonized Light Vehicles Test Procedures (WLTP) in future.

The summary League Table below presents headline company findings. It is based on detailed analysis across a range of carbon and transitional indicators which could have a material impact on company performance. The League Table is designed to serve as a proxy for business readiness in an industry which faces significant disruption as new technologies revolutionize the sector and governments increase efforts to implement the Paris Agreement. Companies placed towards the bottom are deemed less prepared for a low-carbon transition.

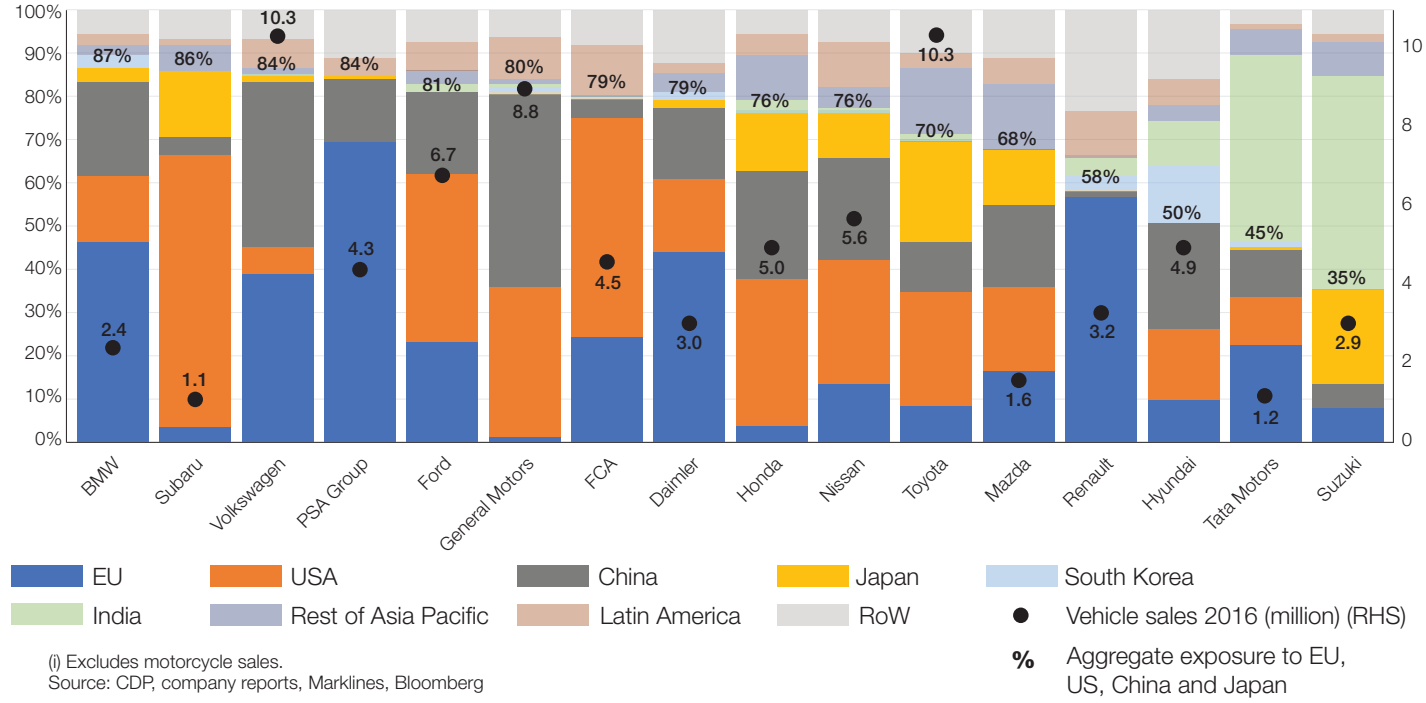
Figure 2: League Table summary [i]

League Table rank	2016 League Table rank	Company [iii]	Ticker	Country	Average market cap 2017 (US$bn)	Unit sales Global market share (2016 - Q3 2017)	League Table weighted rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
1	3	BMW	BMW GR	Germany	62	2%	6.31	6	3	2
2	5	Daimler	DAI GR	Germany	81	3%	6.42	2	5	6
3	4	Toyota	7203 JP	Japan	188	11%	6.87	4	8	3
4	1	Nissan	7201 JP	Japan	42	6%	6.91	7	4	5
5	6	Honda	7267 JP	Japan	54	5%	7.24	3	9	13
6	11	Volkswagen	VOW GR	Germany	82	11%	7.30	12	2	8
7	2	Renault	RNO EU	France	28	3%	7.39	9	10	1
8	14	Tata Motors [ii]	TTMT IN	India / UK	22	1%	7.70	1	11	9
9	8	PSA Group	UG FP	France	19	4%	8.33	8	12	7
10	7	Ford	F US	USA	47	7%	8.49	14	6	11
11	9	Mazda	7261 JP	Japan	9	2%	9.05	5	15	10
12	10	General Motors	GM US	USA	56	9%	9.18	16	1	12
13	13	Hyundai	005380 KS	South Korea	30	5%	9.93	13	7	15
14	15	Suzuki	7269 JP	Japan	23	3%	10.68	11	16	14
15	12	FCA	FCAU US	Italy / USA	20	5%	10.79	15	13	4
16	n/a	Subaru	7270 JP	Japan	28	1%	11.04	10	14	16
					Total	79%				
Weighting								**40%**	**40%**	**20%**

(i) Weighted ranks are calculated for each area. We display non-weighted ranks in this summary for simplicity only.
(ii) Analysis for Tata Motors includes fully owned subsidiary Jaguar Land Rover.
(iii) Kia, Geely (owns Volvo) and Great Wall Motors are non-responders to CDP's 2017 climate change questionnaire and are therefore not included in this report. We encourage investors to raise this lack of transparency in discussions with company management.

Source CDP

Figure 3: Vehicle sales split by region (2016)[i]



(i) Excludes motorcycle sales.
Source: CDP, company reports, Marklines, Bloomberg

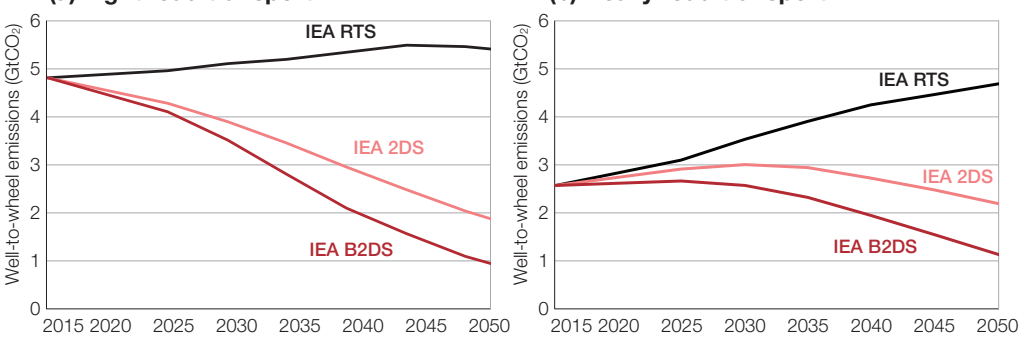
Overview

The automotive sector is in significant transition and on the edge of two waves of technological disruption - the first from advanced vehicles and the second from autonomous, shared driving.

Advanced vehicles such as fuel cell vehicles (FCVs), battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) are game-changing technologies. Market penetration rates are on the rise, helped in part by stricter emissions regulations and falling battery costs. 2017 saw a flood of target announcements for low-emission vehicles from companies - when taken in aggregate, these company targets are in line with the IEA 2DS scenario out to 2025.[6]

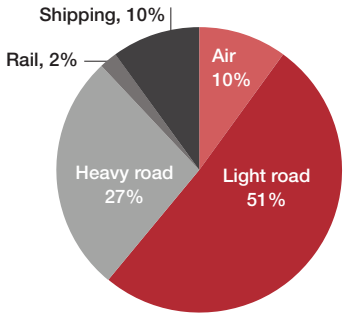
The transport sector accounts for 22% of global CO_2 emissions, and road transport accounts for 77% of that proportion (see Figure 5). Significant decarbonization is required by the sector to fulfil its part in achieving well below 2°C of warming. For the 2DS scenario this equates to a 60% reduction in light road emissions and a 14% reduction in heavy road emissions by 2050 (Figure 4).

Figure 4: Global well-to-wheel emissions scenarios



Source: IEA ETP 2017

Figure 5: Global well-to-wheel emissions split by transport mode



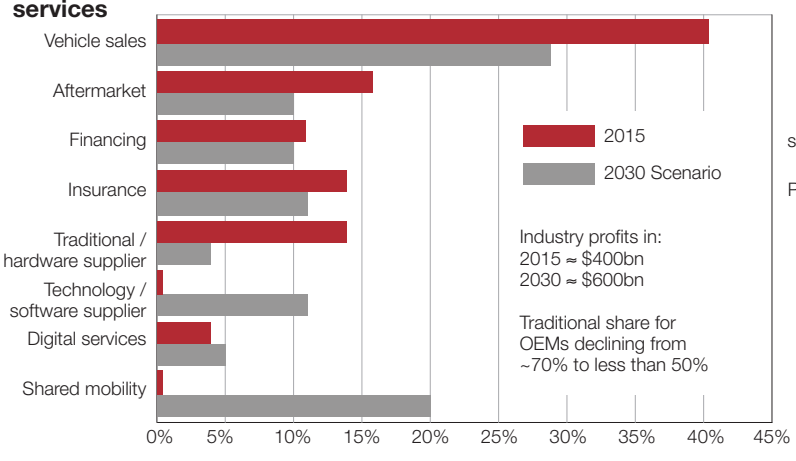
Source: IEA ETP 2017

A whole new automotive ecosystem is emerging; integrating energy generation, storage and transport and the rise of autonomous driving vehicles (ADVs) and mobility as a service (MaaS) will fundamentally change the form and function of the sector. These developments will have a material spill over effect on other sectors, impacting commodity demand in the mining and oil & gas sectors, electricity demand patterns and knock-on effects for suppliers in technology, capital goods and chemicals.

The global car fleet numbers over 1 billion and annual global revenues from vehicle sales are in excess of US$ 2 trillion. However, profits are expected to shift towards tech / software suppliers and ride-sharing services (Figure 6).

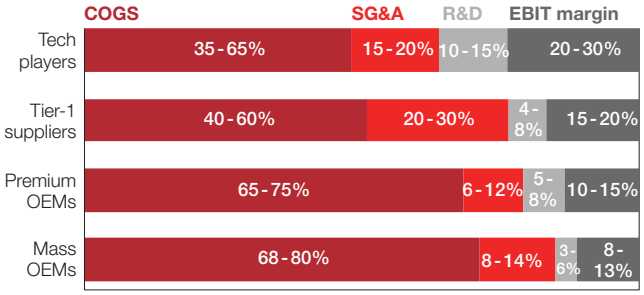
Incumbent OEMs face new competition from technology companies (e.g. Waymo/Google, Apple, Tencent, Baidu), ride-sharing companies (e.g. Uber, Lyft, Didi), electric vehicle specialists (e.g. Tesla) and other start-ups, many of which are coming from China (e.g. Nio). Figure 7 compares typical profit and loss breakdowns for some of these companies.

Figure 6: Profits shifting to tech / software suppliers and ride-sharing services



Source: Strategy& (PwC)

Figure 7: Comparison of profit and loss breakdown



Source: McKinsey

Compared to other industries OEMs have relatively high R&D expenditure as a proportion of sales (average for our sample of 16 companies is 4.6%, compared to 0.4% in extractive sectors such as mining and oil & gas). However, as shown in Figure 7, large technology companies spend even more on R&D and focus more of this spend on disruptive technologies in areas such as software development and machine learning.

Technology companies tend to have more capital flexibility (owing to robust operating margins and large market capitalizations), allowing them to aggressively pursue new opportunities.

In a scenario where 30% of new cars sales are zero emission or plug-in hybrid by 2030, the potential market could add up to US$1 trillion. Additionally, PwC estimate total revenues from shared mobility and connectivity services to add up to US$2.2 trillion by 2030[7]. It's a race to capture a share of these new markets and some OEMs may struggle to keep pace.

6. See Figure 55 on page 31 for further detail.
7. For comparison, today's smartphone market adds up to $0.44 trillion, Connected car report 2017, PwC.

Key report findings

Earnings risks

- **Companies are at risk of missing fleet emissions targets.** For Europe we estimate half our company sample is at risk of paying regulatory fines and some OEMs may require up to 20% of sales from electric vehicles in order to meet 2021 targets.
- **A combination of tightening fuel consumption regulations and NEV share mandates[8] in China present** significant challenges to OEMs in the region.
- **Real-world fleet emissions are on average 30% higher** for passenger vehicles than lab-based tests. OEMs face tougher fleet emissions testing with the introduction of WLTP[9] and must focus on implementing measures which reduce emissions under real-world driving conditions to avoid regulatory penalties.
- **CO_2 compliance costs for internal combustion engine (ICE) vehicles are expected to double by 2021** and increase threefold by 2025 (reaching over $2,200 per vehicle). OEMs may struggle to pass these costs onto consumers which would have a severe effect on profit margins.
- OEMs have **cut manufacturing emissions and energy intensity** in recent years. 15 of the 16 companies featured have taken steps to decarbonize and have reduced emissions and energy intensity of operations.
- **Business resilience to disruptive change varies,** with EBIT margins ranging from 4.5% to 13.7%, up to 65% of vehicle sales in emerging markets, up to 27% luxury vehicle sales, and up to 31% of revenue outside of the core automotive business. As well as capitalizing on new market opportunities, OEMs can focus on other areas to provide some stability and ensure survival.

Opportunities

- **Incumbent OEMs are successfully capturing the advanced vehicle market.** Japanese OEMs dominate the FCV and HEV markets while European and US OEMs have focussed more on BEVs and PHEVs.[10] Market share ratios greater than 1.0 suggest many companies are pursuing low-carbon strategies,[11] and time will tell if these companies are able to maintain this momentum as markets reach a tipping point.
- **Cumulative OEM advanced vehicle targets are in line with the IEA 2DS scenario out to 2025.[12]** If OEMs achieve their sales targets, the electric car stock could reach over 70 million by 2025 (see Figure 41 on page 25). A flood of target announcements were made this year. Some new BEV models planned for release claim ranges in excess of 500km, potentially eradicating range anxiety.
- Li-ion battery prices continue to fall and we expect to see **BEV price parity with ICE vehicles from around 2022.** In a scenario where 30% of new car sales are zero emission or plug-in hybrid by 2030, the **potential EV market could add up to US$1 trillion.**
- **OEMs have taken different strategies in developing mobility as a service (MaaS) and autonomous driving vehicle (ADV) capabilities,** with some companies focusing on developing in-house technologies while others gain expertise through acquisitions of companies that specialise in these fields. OEMs have invested heavily in companies developing MaaS and ADVs (over $11 billion since 2015) and have formed numerous strategic partnerships to facilitate deployment of the technologies.
- **R&D as a proportion of sales averages at 5%** for the company sample, high compared to most sectors but **lower than the 10-15% seen from technology companies.** Some companies need to improve R&D efficiency and perhaps focus efforts more towards disruptive technologies.
- Patent data suggests **Japanese OEMs lead on advanced vehicle and battery innovation while US OEMs lead on patents for ADVs.**
- **Companies source up to 33% of their energy needs from renewable sources. Three companies are members of the RE100 initiative.** With energy accounting for up to 10% of operational costs, smart energy solutions offer an opportunity to optimize costs and reduce manufacturing emissions.

Long term climate resilience

- The use of **Life-Cycle Analysis to assess emissions** from 'well to wheel' is well-established within the industry, with all companies conducting some form of the analysis.
- **OEMs are heavily dependent on their supply chains for the continuity of business operations.** Five of the 16 companies engage with all of the suppliers in their value chains on climate-related issues.
- Seven companies are committed to and support the **Science Based Targets initiative** (SBTi) which will publish its decarbonization pathway for the sector this year.
- **Fleet emissions account for around 80% of total automotive emissions** yet three OEMs do not set Scope 3 emissions reduction targets. With its "Environmental Challenge 2050", Toyota aim to reach zero CO_2 emissions in the entire vehicle life cycle.
- **Governance and remuneration structures lack alignment with a low-carbon transition,** with a marked difference in performance between European and other global OEMs. Companies were found to exhibit weak to average performance on climate-related remuneration, largely due to the absence of climate-related long-term incentive programs.

8. China has announced new energy vehicles (NEV) share mandates of 10% for 2019 and 12% for 2020 (though as long-range NEVs can receive up to five credits, mandatory shares are more like 2.5-3% in 2019 and 3.5-4% in 2020).
9. Many regions will be implementing the Worldwide Harmonized Light Vehicles Test Procedures (WLTP) in future.
10. Fuel cell vehicles (FCVs), battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs) and mild hybrid vehicles (HEVs).
11. If the market share ratio is greater than 1.0 it indicates that a company's market share of that particular technology is greater than their share of the total vehicle market, see page 27-28 for further detail.
12. Includes all company announcements, including Tesla and Chinese OEMs, in addition to sample of 16 companies.

Company highlights

#1 BMW takes the top spot, moving up from third place in the 2016 report. It ranks consistently well across most metrics. It was an early mover in electric vehicles with its i3 model series and has a relatively aggressive advanced vehicle target (15 – 25% of sales from BEV / PHEV by 2025). It is active in ADVs through its partnership with Intel & Mobileye and has exposure to MaaS with its companies DriveNow, Parknow, ChargeNow and ReachNow. It ranks second for climate governance & strategy.

#2 Daimler has a clear strategic focus on the future of mobility, represented by CASE (Connected, Autonomous, Shared and Electric). It has ambitious EV targets (25% of Mercedes sales from BEVs by 2025) which will be championed under its new brand EQ. It has strong positioning in MaaS with Mytaxi and Car2Go and a promising partnership with Bosch for ADVs. It ranks first for business resilience with a relatively high EBIT margin (9%), high proportion of luxury vehicle sales and diversification in trucks. We note it is considering a new corporate structure for 2019 to better prepare for a low-carbon transition.

#3 Toyota has a comprehensive low-carbon transition plan with its "Environmental Challenge 2050"; looking to reach zero CO_2 emissions in the entire vehicle life cycle. It works closely with its suppliers to achieve this through its 'Green Purchasing Guidelines'. It has dominated the hybrid market with successful models such as the Prius and its expertise on fuel cell vehicles could pay off if the technology scales up. Although a late mover on pure electric vehicles, its recent target plans for more than 10 BEV models by the early 2020s.

#4 Nissan has dominated the electric car market with the Nissan Leaf. With its new and improved 2018 model (241km EPA range) it looks set to continue this success. The new alliance 2022 plan (Renault-Nissan-Mitsubishi alliance) aims to launch 12 new zero-emission vehicles by 2022; however, unlike other OEMs, no EV sales target has been communicated with the plan. It has strong performance on innovation with high numbers of patents for FCVs, electric vehicles and Li-ion batteries and an ambitious ADV target (Level 5 by 2022).

#5 Honda ranks first for overall fleet emissions performance. It has already significantly beaten its 2020 target in Japan and has the fourth strongest performance in the US. It is let down slightly by poorer performance in the EU where it is at risk of having to pay regulatory fines in 2021 (but relative market exposure is much lower). Its motorcycle business provides good diversification and it should benefit from its exposure to growth markets such as Southeast Asia. It ranks second in our advanced vehicles section, with its Clarity BEV, FCV and PHEV models performing well in our technical review. However, its Level 4 automation target for 2025 is less ambitious than other OEMs.

#6 Volkswagen rises in ranking to take sixth place. The emissions scandal catalyzed the company into action and since announcing its 'strategy 2025' plan (aiming to become the global leader in e-mobility, June 2016), group shares have risen 50%. In our view, with its Roadmap-E initiative, it has the most aggressive EV target (up to 25% of sales from BEVs by 2025). It has a number of partnerships with companies focusing on MaaS and ADVs (most recently ADV start-up Aurora). However, for both the EU and China, an increased rate of fleet emissions reduction is required to meet future targets and avoid regulatory penalties.

#7 Renault drops in ranking from 2nd in the 2016 League Table. It has not reduced manufacturing emissions and energy intensity as quickly as others since 2010 and in China it requires a relatively high reduction rate in Joint Venture (JV) passenger vehicle fleet emissions (7.3% p.a.) to meet its 2020 target. However, it ranks first for climate governance & strategy, demonstrating strong supplier engagement and conducting comprehensive life-cycle analysis. Its high exposure to emerging markets (approx. 40% of vehicle sales) should provide some resilience to disruptive forces. With its alliance partner Nissan, it has an ambitious ADV target (Level 5 2022).

#8 Tata Motors shows the most improvement from the 2016 report. It ranks first for managing transition risks. It has significantly reduced Jaguar Land Rover (JLR) fleet emissions in the EU and its exposure to emerging markets, luxury vehicles and trucks may provide some resilience to disruptive technologies. It has lagged other OEMs on entering the advanced vehicle market; however, Tata Motors is to supply BEVs (Tigor model) to the Indian government and every JLR vehicle launched from 2020 is to be electrified. JLR's first BEV, the I-Pace, is one to watch.

#9 PSA Group has had strong fleet emissions performance in the EU, having reduced passenger vehicle fleet emissions by 4.3% p.a. since 2010. However, with the acquisition of Opel, it now faces a bigger challenge to meet 2021 regulatory targets.[13] It has the lowest manufacturing emissions intensity and ranks first for climate-related remuneration. However, its Level 4 automation target for 2025 lacks ambition and it lags other OEMs in capturing a share of the advanced vehicle market.

#10 Ford has poor fleet emissions performance across all regions. For the EU, US and China an increased rate of emissions reduction is required to meet regulatory targets in 2020/21. Company Scope 1, 2 & 3 emissions reduction targets are not as aggressive as other OEMs. However, it ranks second in our ADVs and MaaS section. It's aiming for Level 4 autonomy by 2021 and has actively invested and partnered with companies focusing in these areas (e.g. $1bn investment in Argo AI and strategic partnership with Alibaba).

13. PSA Group acquired Opel / Vauxhall from General Motors in August 2017. We note that it is considering legal action against General Motors for being misled regarding Opel's emissions strategy, Reuters.

#11 Mazda ranks well for managing transition risks but poorly for transition opportunities. It has strong fleet emissions performance in the US, China and Japan and its "Sustainable Zoom-Zoom 2030" strategy has ambitious emissions reduction targets. Of note in this strategy is its focus on 'Jinba-Ittai' (oneness between car and driver). In 2019, it plans to introduce its new compression ignition technology, SKYACTIV-X, which it says could be up to 30% more fuel-efficient. Within our company sample it has been less active in the areas of advanced vehicles, ADVs and MaaS but its new partnership with Toyota looks to focus on these areas.

#12 General Motors ranks first for transition opportunities but last for managing transition risks. Significant reductions in fleet emissions are needed in both the US and China to meet future regulatory targets[13] and it is the only company to show little evidence of conducting in depth life-cycle analysis. In contrast, it is working towards "an all-electric future" and is the frontrunner for ADV and MaaS capabilities. It is aiming to roll-out a fully self-driving ridesharing service by 2019 (Level 4 autonomy).

#13 Hyundai ranks first in our technical review of advanced vehicles, with the Ioniq Electric achieving the top spot for BEVs. It has devoted $2bn over a 5-year period to develop ADV technology and through its recent partnership with Aurora, is aiming for Level 4 autonomy by 2021. We note its recent pledge to invest $22 bn over the next 5 years in EVs, ADVs and other technology (includes affiliate Kia). However, it has poor fleet emissions performance and ranks second last for climate governance & strategy owing to poor supplier engagement and a lack of climate-related remuneration.

#14 Suzuki ranks last for transition opportunities. It shows little evidence of investment in ADVs and MaaS. Unlike other OEMs it has not communicated an automation target and it lags competitors in development of advanced vehicles. However, it aims to launch its first electric vehicle in India in 2020. Its motorcycle business provides some diversification and it should benefit from high exposure to growth markets such as India and Southeast Asia. It ranks poorly for climate governance & strategy and is the only OEM where manufacturing emissions and energy intensities have increased since 2010.

#15 FCA is still surrounded by uncertainty regarding CEO Sergio Marchionne's successor (plans to retire April 2019) and is often the subject of merger speculation.[14] A new five-year business plan is to be communicated by Q2 2018. Currently the company lags competitors in the areas of ADVs, MaaS and electrification. It has comparatively weak emissions reduction targets and poor fleet emissions performance (it is at risk of having to pay regulatory fines). However, it has strong supplier engagement on climate related issues, conducts in depth life-cycle analysis and aims to increase renewable energy use.

#16 Subaru scores poorly across most metrics. It ranks last for climate governance & strategy; showing little sign of engaging suppliers on climate-related issues and has the weakest emissions reduction targets. It is the only OEM in danger of missing its 2020 fleet emissions target in Japan. However, it has had successful sales of hybrid vehicles and is looking to launch a PHEV at the end of 2018 and a BEV in 2021. It has the highest EBIT margin within the company sample, affording it more room to manoeuvre in a low-carbon transition.

Company selection and classification

Companies were selected from a list of the largest publicly listed global automotive companies, based on average market capitalization for 12 months to Q2 2017 and those that responded to CDP's 2017 climate change information request. All 15 of the companies featured in CDP's 2016 automotive report are included again, with the addition of Subaru.

Non-responding companies

We highlight the following companies as non-responders to CDP's 2017 climate change questionnaire and are therefore not included in this report. We encourage investors to raise this lack of transparency in discussions with company management.

Figure 8: Non-responders to CDP

Company	Ticker	Country	Average market cap 2017 (US$bn)	Unit sales Global market share (2016 - Q3 2017)	First approached by CDP	Comments
Geely	175 HK	China	20	1.6%	2011	Geely is a leading automobile manufacturer in China. The company owns Volvo, which are to use electric motors in all cars from 2019.
Great Wall	601633 CH	China	15	1.1%	2008	Great Wall Motor Company Limited is China's largest SUV and pickup manufacturer.
Kia	000270 KS	South Korea	13	3.0%	2007	Kia (minority owned by Hyundai, which owns a 34% stake) are the second largest auto manufacturer in South Korea.

Source: CDP

14. Most recently there have been talks of a technical partnership with Hyundai, but no merger.

Linking our findings to investment choices

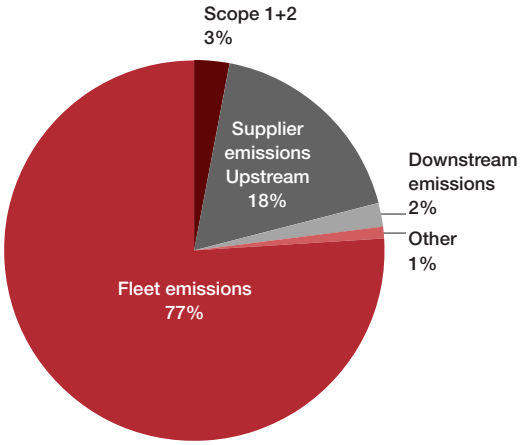
We recognize that investment decisions are based on a multitude of different factors and that some of these can be misaligned with emissions-reduction efforts. Our League Table identifies company readiness for the transition to a low-carbon economy. We would flag that companies towards the bottom of our League Table are higher risk investments from a climate change perspective than those towards the top.

Methodology

We score each company based on a number of metrics which are ranked and then weighted within each key area (see Figure 10 below for metric weightings within each key area). We then assign traffic light colours based on these weighted ranks. We calculate the overall League Table score by collating the weighted ranks for each key area.

Each of the key areas has a separate chapter within this report. We disclose the precise methodology for how we rank each metric in an appendix.

Figure 9: Automotive industry emissions split by categories[i]:



(i) Based on OEM's responses to CDP's 2017 questionnaire.
Source: CDP

Figure 10: A summary of key areas, associated metrics and weights within the League Table

Key area in League Table	Financial impact	Metrics		Key area weighting
Transition risks	• Tightening emissions regulation - increasing compliance costs for traditional car engines. • Risk of reputational damage and financial penalties for missing fleet emissions targets, impacting earnings. • Shift in consumer preferences (e.g. diesel sales in Europe, popularity of EVs, ride-sharing), revenue risk to OEMs that lack sufficient fleet diversification.	• **Fleet emissions performance** (passenger vehicles & LCVs: distance to target and trend) *EU, US, China, Japan (weightings by normalized market exposure)* • **Manufacturing emissions and energy intensity** (level and trend) *Emissions intensity (50%), Energy intensity (50%)* • **Business resilience** *EBIT margin (25%), Non-automotive revenue (25%), Exposure to emerging markets (25%), % Luxury vehicle sales (25%)*	70% 10% 20%	40%
Transition opportunities	• Growing demand for advanced vehicles, opportunity to capture share of nascent market and de-risk revenues from switch in consumer demand for ICEs. • Opportunities for new revenue streams from new mobility services and autonomous, connected vehicles and positioning business models to changing demand for transport and services. • Importance of focused R&D spend in the face of competition from high spending technology companies.	• **Advanced vehicles** (includes FCV, BEV, PHEV and HEV) *Market share ratio (30%), Technical review (25%), Targets (25%) and Review of patents filed (20%)* • **Autonomous vehicles & car sharing** *Investments & acquisitions (20%), Partnerships & business areas (15%), Targets (30%), Patents filed / ADV road tests (35%)* • **R&D spend as % of sales** • **Renewable energy use & targets**	50% 40% 5% 5%	40%
Climate governance & strategy	• Ambitious emissions reduction targets and governance structures are indicative of OEMs' strategy to avoid future climate-related financial costs.	• **Supplier engagement** • **Emissions reduction targets** • **Emissions data assurance** • **Use of internal CO_2 price** • **Climate-related remuneration** • **Board level climate expertise** • **Water intensity and management** • **CDP score**	25% 25% 5% 5% 15% 10% 10% 5%	20%

Source: CDP, company reports

Transition risks

- Companies are at risk of missing fleet emissions targets: average fleet emissions reduction rate since 2010 of 2.9% p.a. compared to 5.3% p.a. required to meet future targets.
- Tata Motors ranks first. It has significantly reduced Jaguar Land Rover fleet emissions in the EU and its exposure to emerging markets and luxury vehicles may provide some resilience to disruptive technologies.
- General Motors ranks last. Fleet emissions are far above target levels, it lacks diversification and has not reduced manufacturing emissions and energy intensity as fast as others.
- Tata Motors, Daimler and Honda rank highest. Ford, FCA and General Motors rank lowest.

Overview

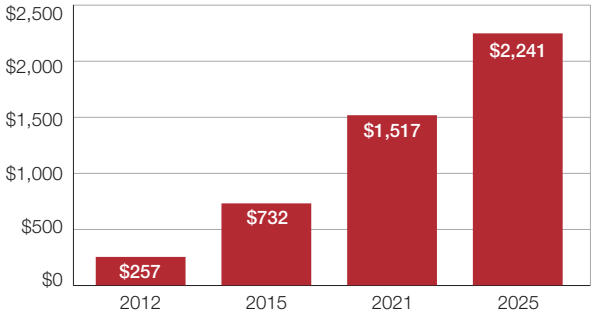
Most major vehicle markets are tightening regulations on fleet emissions, with significant penalties for non-compliance. Currently 87% of global passenger vehicle sales are covered by country level emissions regulation. With the share of diesel vehicles in decline and rising popularity of SUVs, companies face an even greater challenge and must increase penetration rates of low-emission vehicles to avoid missing regulatory targets and paying substantial fines.

Compliance costs for internal combustion engine (ICE) vehicles are expected to increase (Figure 11) and OEM business models face significant disruption from advanced vehicle technologies and autonomous, shared driving.

In this section we assess company exposure and resilience to transition risks across the following areas:

Fleet emissions: We focus on the fleet emissions regulation across the EU, US, China and Japan. We assess OEMs past performance at reducing their fleet emissions along with current performance relative to company specific targets.

Figure 11: Average CO_2 compliance cost per vehicle



Source: CDP estimates, ICCT, Goldman Sachs, IHS, HSBC

Manufacturing emissions & energy intensity: We assess the extent to which companies have reduced their operational emissions and energy intensities and identify those with the lowest intensity levels.

Business resilience: We identify OEMs that are potentially more resilient to disruptive forces, focusing on emerging market exposure, levels of diversification, share of luxury vehicles and EBIT margins.

Figure 12: Transition risks summary

Company	Fleet emissions	Manufacturing emissions & energy	Business resilience	Overall weighted rank	Transition risks rank
Tata Motors (i)	2	9	3	5.9	1
Daimler	4	4	1	5.9	2
Honda	1	6	9	6.3	3
Toyota	7	10	2	6.6	4
Mazda	6	1	10	6.8	5
BMW	10	3	6	7.2	6
Nissan	3	16	13	7.2	7
PSA Group	5	7	12	7.3	8
Renault	8	11	11	7.5	9
Subaru	9	12	14	7.9	10
Suzuki	11	13	4	8.4	11
Volkswagen	12	14	7	8.6	12
Hyundai	13	8	8	10.1	13
Ford	14	2	16	10.6	14
FCA	16	5	5	12.6	15
General Motors	15	15	15	13.3	16
Weighting	**70%**	**10%**	**20%**		

(i) Analysis for Tata Motors includes fully owned subsidiary Jaguar Land Rover.

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

Fleet emissions

Road transport accounts for 17% of global CO_2 emissions[15] and fleet emissions (Scope 3 category 11)[16] account for approximately 80% of total automotive emissions.

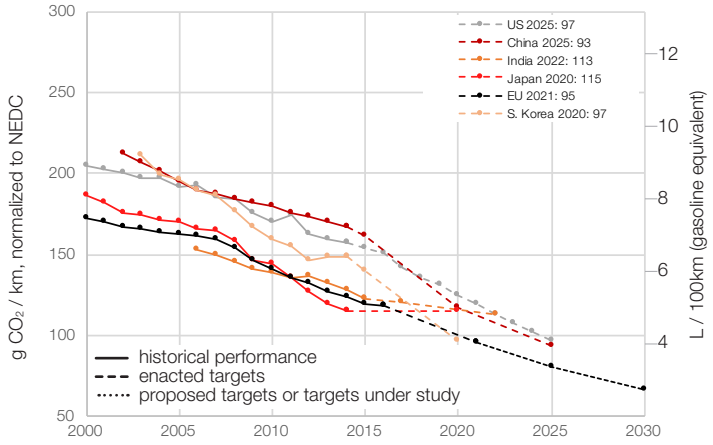
We focus on the fleet emissions regulation across the EU, US, China and Japan (accounting for 74% of passenger vehicle demand). We assess OEMs' past performance at reducing their fleet emissions along with current performance relative to company specific targets.

We calculate the normalized sales exposure for each OEM to these four markets, and multiply it by the respective overall (weighted) rank for each market. This gives the overall fleet emissions weighted rank as shown in Figure 14.[17]

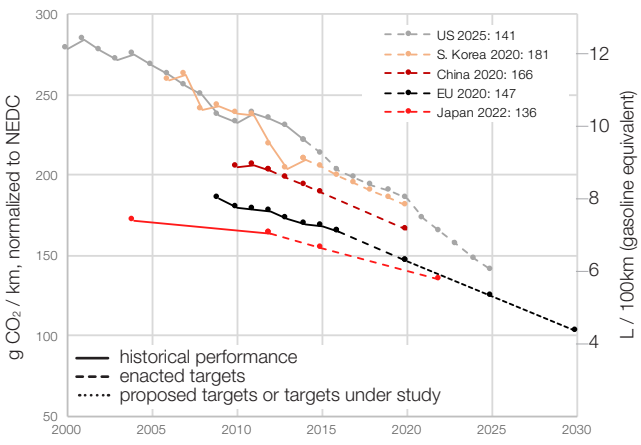
The figures below provide a summary of fleet emissions regulations across different regions for both passenger vehicles and light-commercial vehicles (LCVs). Different schemes use different measures, but are essentially regulating the same thing: fleet carbon emissions. Many regions will be implementing a standardized testing procedure, the Worldwide Harmonized Light Vehicles Test Procedures (WLTP) over the coming years.[18]

Figure 13: Fleet emissions performance and targets by region

(a) Passenger vehicles (PVs)



(b) Light commercial vehicles (LCVs)



Source: CDP, International Council on Clean Transport (ICCT)

Figure 14: Fleet emissions summary

Company	EU emissions		US emissions		China emissions		Japan emissions		Overall weighted rank	Overall rank
	Rank	Exposure to market (i)	Rank	Exposure to market (i)	Rank	Exposure to market (i)	Rank	Exposure to market (i)		
Honda	13	5%	4	45%	5	33%	1	17%	4.9	1
Tata Motors	1	68%	n/a	0%	14	32%	n/a	0%	5.2	2
Nissan	3	18%	2	37%	11	32%	3	13%	5.6	3
Daimler	4	57%	5	22%	1	22%	n/a	0%	6.0	4
PSA Group	5	83%	n/a	0%	7	17%	n/a	0%	6.2	5
Mazda	12	25%	1	29%	3	28%	4	19%	6.2	6
Toyota	2	13%	7	37%	6	17%	2	33%	6.4	7
Renault	6	98%	n/a	0%	12	2%	n/a	0%	6.4	8
Subaru	11	4%	3	73%	4	5%	6	17%	6.8	9
BMW	7	55%	8	19%	2	26%	n/a	0%	7.0	10
Suzuki	10	24%	n/a	0%	9	14%	5	62%	8.1	11
Volkswagen	8	47%	12	7%	8	46%	n/a	0%	8.1	12
Hyundai	14	20%	6	32%	10	48%	n/a	0%	10.4	13
Ford	9	29%	10	48%	13	23%	n/a	0%	10.9	14
General Motors	n/a	0%	9	44%	16	56%	n/a	0%	14.1	15
FCA	15	31%	11	64%	15	5%	n/a	0%	14.7	16

(i) Normalized sales exposure to four key markets. Exposure shown as 0% where sales volumes are low enough to be exempt from regional emissions targets. For a full breakdown of sales by region, see Figure 3 on page 4.

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

15. IEA ETP 2017
16. Scope 3 category 11 – use of sold products, see Figure 9 on page 9 for emissions breakdown.
17. We outline the detailed methodology for our assessment in Appendix III on page 59.
18. See box "Real-world CO_2 emissions" on page 18.

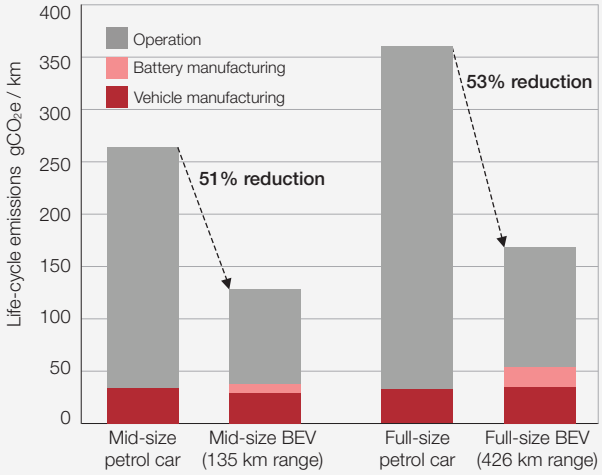
Life-cycle analysis – Looking under the bonnet[19]

Life-cycle analysis (LCA) provides a way of capturing the full impacts of a product or technology from 'cradle to grave', or 'well to wheel' and has increasingly become important as a way of looking at environmental impacts on a holistic basis. This is particularly pertinent in the context of the excitement over advanced vehicles offering the option to radically reduce CO_2 emissions by displacing the use of fossil fuels with a cleaner form of energy through electricity or hydrogen fuel cells.

However, while LCA provides a powerful way of comparing products such as cars across the board, LCA studies need to be scrutinised. For cars this means understanding the boundaries and assumptions being used. For example, the use of heavy metals for battery manufacturing, the electricity mix used for charging the battery and the disposal of the used battery, are key aspects to be considered to identify possible sources of increased environmental impacts.[20]

As ever, it is important to define the universe of cars being compared – here there are two factors worth noting – firstly the generic use of the word "electric" cars or EVs over conventional cars. This category includes purely battery-driven electric cars (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and extended range electric vehicles (E-REVs). These are then compared to a "typical" car which may not always capture the full range within these categories.

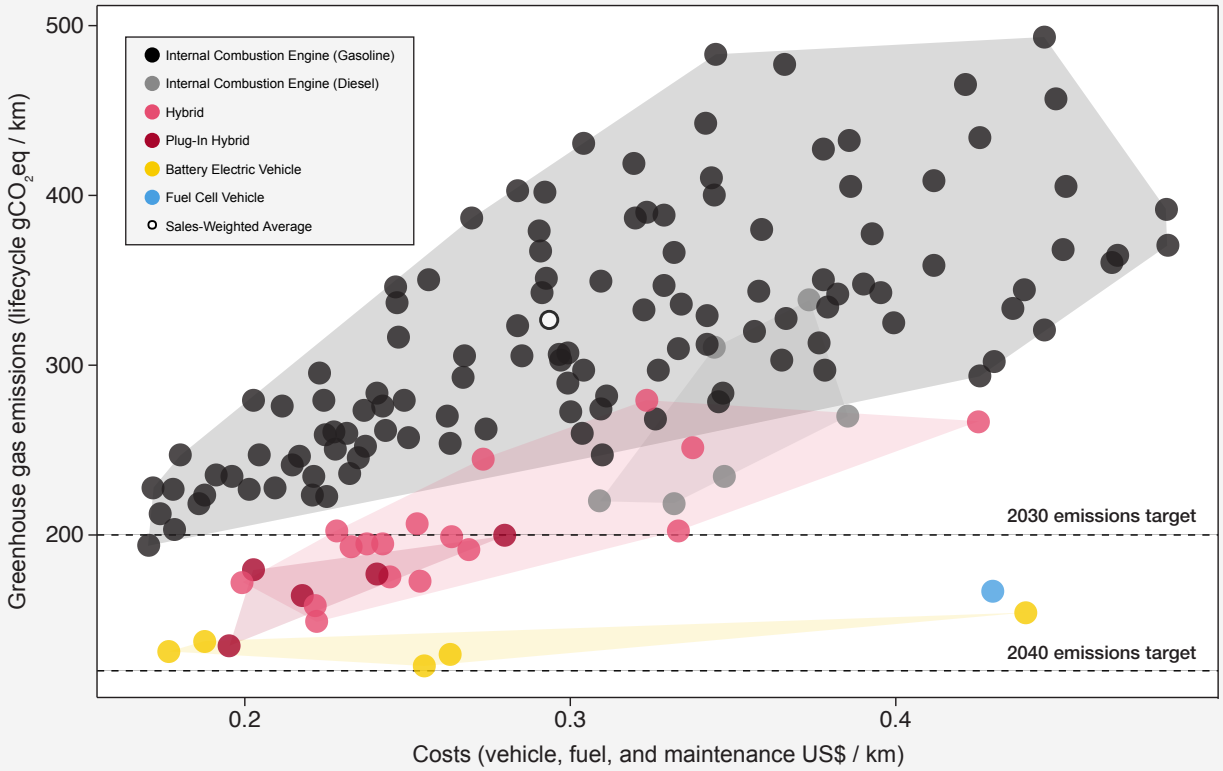
Figure 15: Life-cycle emissions ICE vs. BEV



Source: Union of Concerned Scientists

Figure 15 illustrates that the internal combustion engine vehicle (ICE) has approximately twice the global warming potential when compared to BEVs of a similar weight class, mainly due to the CO_2 emissions during the use phase (it should be noted that BEVs have more emissions in the manufacturing stage as a result of battery manufacturing). MIT recently conducted an in depth LCA study looking across numerous vehicle types, the results of which can be seen in Figure 16.

Figure 16: Life-cycle emissions vs. cost (ii)



(ii) Assumptions include electricity emissions of 600 gCO_2e/kWh (US average mix)
Source: Massachusetts Institute of Technology (MIT), http://carboncounter.com/

The significant potential by BEVs to reduce emissions in the use phase has been the main focus for regulatory policy targeting the up-take of electric cars. This has been accelerated by the need to address the high concentration of air pollutants in most major cities which has resulted in breaches to air quality standards. The transport sector accounts for around 22% of anthropogenic CO_2 emissions with forecasts for light duty vehicles expected to grow over time compounding this problem.

19. We analyse the extent to which companies are using life-cycle analysis (LCA) in the climate governance & strategy section (see page 39).
20. Life-cycle assessment of future electric and hybrid vehicles: a cradle-to-grave systems engineering approach - Carla Tagliaferri et al.

The electricity mix assumption for the supply of electricity is also a crucial part of the equation – the additional electricity demand for higher adoption of electric vehicle ownership will need to be met by increased power generation. The type of power generation capacity to fill this requirement will dictate the potential reduction in CO_2 emissions.

A study in the EU[21] on different penetration rates of electric cars finds that a high adoption rate could see electric cars reach levels of 4-5% of total electricity demand in several European countries by 2030. Should electric car penetration reach 80% by 2050, the energy system would require an additional 150 GW of generation capacity. As well as the larger requirement in terms of power generation capacity, the pattern of smart charging would also put a significant strain on the delivery of power with management required of grid constraints and smoothing of load profiles. To optimise the reduction of carbon emissions, renewable generation would be the best solution which requires handling the intermittent nature of wind and solar against the demand profile from the usage of electric cars.

There is no doubt that BEVs offer the technology to transform the CO_2 emissions from the transport sector – however, the benefits from adopting this "zero" carbon option should take into consideration impacts elsewhere and regulators need to take a more holistic view. New studies have started looking at the broader implications of BEVs for transport from a social and economic point of view looking at positive and negative trade-offs.[22] We can continue to expect a flurry of studies examining the merits or otherwise of BEVs but there is no doubt with consumer disenchantment with the diesel car, the drive to an electric car future has started and to reap the benefits, impacts across the system need to be managed.

EU fleet emissions

15 of the 16 companies in our study are exposed to the EU auto market (which has the most stringent regulatory targets), together representing a market share of 94%. In this section, we assess whether they are on track to meet the EU fleet emissions targets for 2021. The EU fleet-wide targets for 2021 are 95 gCO_2/km for passenger vehicles and 147 gCO_2/km for Light Commercial vehicles (LCVs). These targets are adjusted to give a specific target for each OEM according to its fleet average weight. In November 2017, the European Commission proposed new standards – for both cars and vans, fleet emissions are to be 15% lower in 2025 than 2021 and 30% lower by 2030.

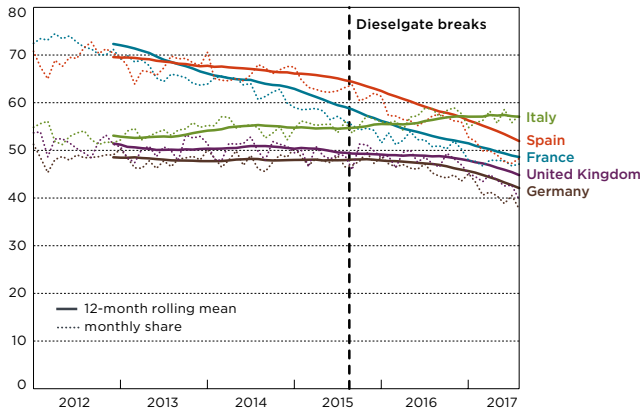
For each OEM that we consider to be off track to meet its 2021 target, we estimate the potential financial penalty based on the penalty regime. OEMs failing to meet their targets will face a penalty of €95 per every gram of exceedance (per vehicle sold).

We differentiate OEM performance across EU emissions using the following metrics:

Metric 1) Passenger vehicle (PV) performance
This metric focuses on the extent to which companies have reduced their PV fleet emissions over the period 2010 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2021 targets.

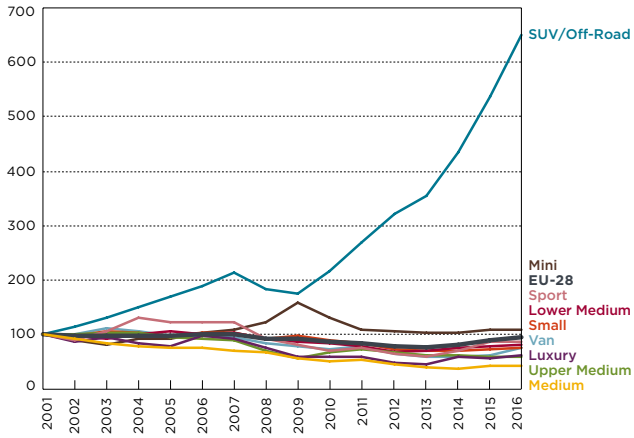
Metric 2) Light commercial vehicles (LCV) performance
This metric focuses on the extent to which companies have reduced their LCV fleet emissions over the period 2012 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2020 targets.

Figure 17: Diesel share of new car registrations (%)



Source: ICCT

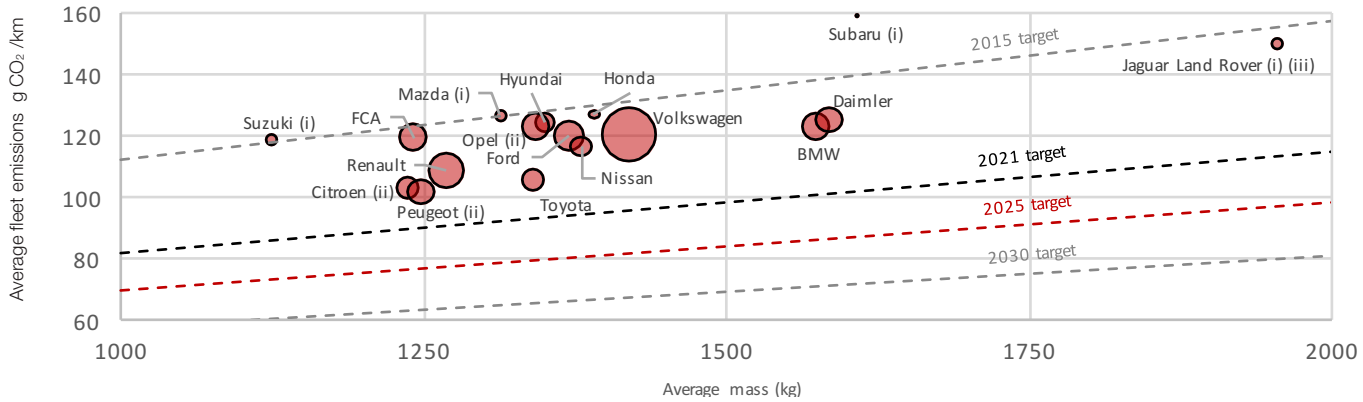
Figure 18: Car registrations by segment (indexed 2001)



Source: ICCT

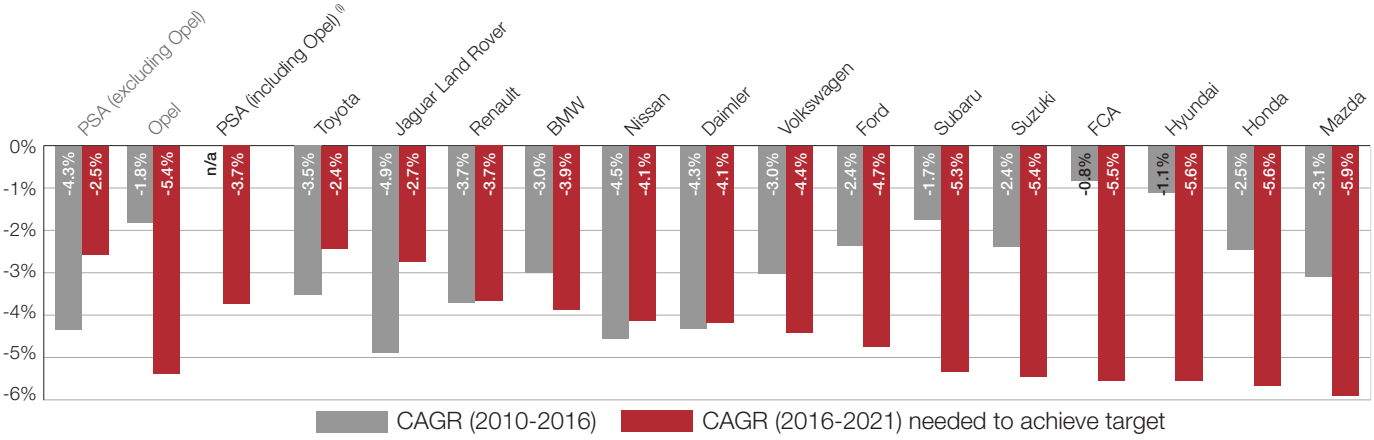
21. Assessing the status of electrification of road transport passenger vehicles and potential future implications for the environment and European energy system – Oko-Institut e.V.
22. Combined application of multi-criteria optimisation and life-cycle sustainability assessment for optimal distribution of alternative cars in US – Nuri Cihat Onat et al.

Figure 19: (EU) Passenger vehicles: Average fleet emissions (2016) vs. vehicle weight and targets



Bubble size = number of vehicle registrations
(i) Jaguar Land Rover, Mazda, Subaru and Suzuki had fewer than 300,000 registrations. Companies have separate niche derogation targets.
(ii) We note that Peugot and Citroen are in separate pools. PSA acquired Opel / Vauxhall from General Motors in August 2017.
(iii) Jaguar Land Rover is fully owned by Tata Motors.
Source: CDP, company reports, EEA, ICCT

Figure 20: (EU) Passenger vehicles: Comparison of past progress and future performance needed to meet the 2021 target



(i) PSA Group have been ranked on the past performance of Peugeot and Citroen pools only and CAGR needed to achieve 2021 target for Peugeot, Citroen and Opel.
Source: CDP, company reports, EEA, ICCT

Highlights

- On average across the 16 companies, passenger vehicle (PV) fleet emissions were reduced 3.0% p.a. between 2010 and 2016. However, to meet EU 2021 targets an average reduction rate of 4.5% p.a. is required. With the share of diesel vehicles in decline and share of SUVs on the rise (Figures 17 & 18). companies need to increase their efforts and increase penetration rates of advanced vehicles to avoid paying regulatory fines. (It is a brighter story for light commercial vehicles (LCVs) where OEMs reduced fleet emissions at an average of 2.4% p.a. between 2012 and 2016 and require a lower average reduction rate of 1.9% p.a. to meet 2020 targets).

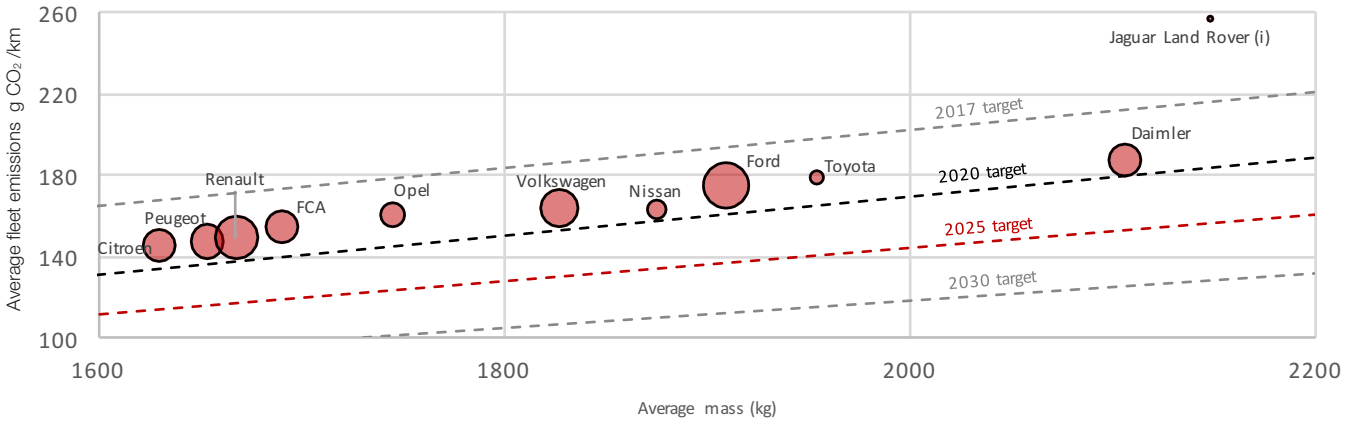
- Jaguar Land Rover ranks first. For PVs, it has a niche derogation target of 130 gCO_2 / km (due to fewer than 300,000 registrations) which it should comfortably meet (helped in part by its electrification strategy and the launch of the I-Pace in 2018). Toyota is a close second with strong historical performance (PV CAGR 2010-2016 of -3.5%) and the lowest reduction rate required to meet its PV 2021 target (CAGR 2016-2021 of -2.4%, see Figure 20).

- PSA Group now have a bigger challenge on their hands to meet 2021 fleet emissions targets with the acquisition of Opel. We note that Peugeot, Citroen and Opel are currently in separate pools[23] (Figures 19 & 21). Opel requires a much higher PV fleet emissions reduction rate (5.4% p.a.) compared to Peugeot and Citroen (2.5% p.a.). It may be beneficial for PSA to group all vehicle sales into one pool in order to avoid regulatory fines (see Figure 23).

- FCA ranks last. Its historical fleet emissions reduction rates for both PVs and LCVs are the worst (only 0.8% p.a. for PVs and 0.3% for LCVs, see Figures 20 & 22). It therefore requires much more aggressive reduction rates to meet the 2021 targets and we estimate it is at risk of having to pay substantial regulatory fines (Figure 23). With strong sales performance of higher emitting brands like Jeep and relatively weak electrification targets (see Figure 55 on page 31) it may struggle to meet its 2021 targets.

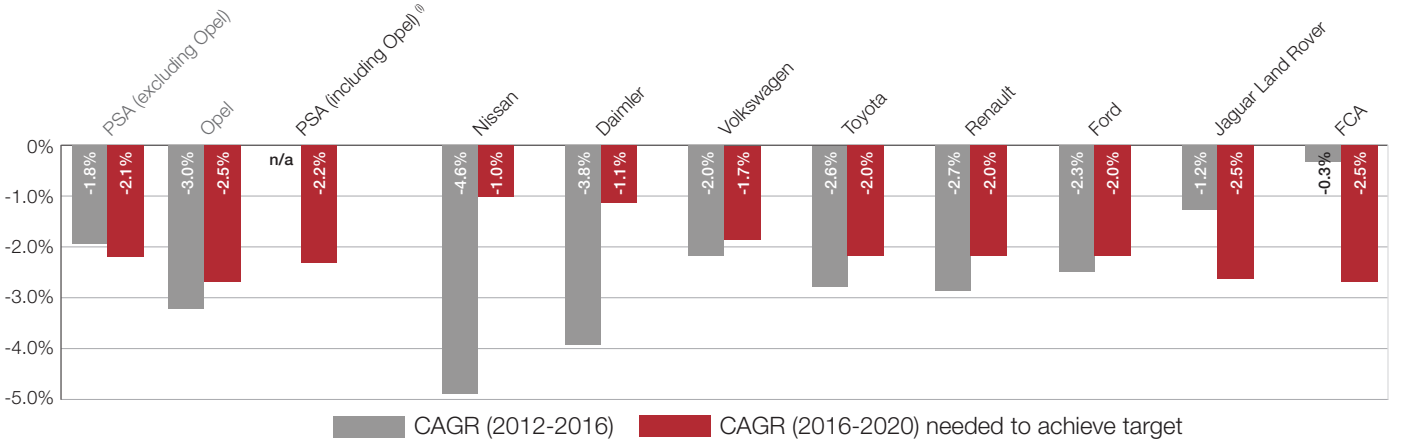
23. Each brand may form a pool with other brands to share a target (calculated on the basis of the fleet of the pool).

Figure 21: (EU) LCVs: Average fleet emissions (2016) vs. vehicle weight and targets



Bubble size = number of vehicle registrations
(i) Jaguar Land Rover (fully owned by Tata Motors) had fewer than 22,000 registrations and has a separate niche derogation target.
Source: CDP, company reports, EEA, ICCT

Figure 22: (EU) LCVs: Comparison of past progress and future performance needed to meet the 2021 target



(i) PSA Group have been ranked on the past performance of Peugeot and Citroen pools only and CAGR needed to achieve 2021 target for Peugeot, Citroen and Opel.
Source: CDP, company reports, EEA, ICCT

Figure 23: Estimated penalties for OEMs that are off track to meet their targets(i)

Company	Passenger vehicles (PVs)			Light commercial vehicles (LCVs)		Total penalty (EURm)	Penalty as % of EBIT (2016)
	% miss 2021 target	% BEV sales required to meet target (ii)	PV penalty (EURm)	% miss 2020 target	LCV penalty (EURm)		
FCA	10.6%	13% - 20%	846	4.4%	93	938	15%
Mazda	3.7%	4% - 7%	72	n/a	-	72	6.9%
Ford	4.5%	5% - 8%	413	BEAT	-	413	5.9%
Hyundai	4.8%	12% - 18%	210	n/a	-	210	5.2%
Suzuki	6.7%	6% - 10%	110	n/a	-	110	4.9%
Honda	4.3%	6% - 10%	59	n/a	-	59	0.8%
Subaru	6.7%	8% - 13%	23	n/a	-	23	0.7%
Opel	3.6%	3% - 5%	313	BEAT	-	313	n/a
Jaguar Land Rover	BEAT		-	1.3%	2.2	2.2	0.1%
PSA (including Opel)	BEAT		-	BEAT	-		

(i) Estimated penalties are for illustrative purposes only and have not been used to rank companies. We recognise that there are a number of measures companies can take to ensure that targets are met and that many of the above companies state they are committed to complying with emissions regulations. See methodology on page 59 for further detail.

(ii) Estimated share of zero emission vehicles needed in order to meet 2021 target. (Companies may of course choose to further reduce emissions from ICE vehicles or sell PHEVs and HEVs.)

Source: CDP

US fleet emissions

13 of the 16 OEMs in our study are exposed to the US market, together representing a market share of 95%.

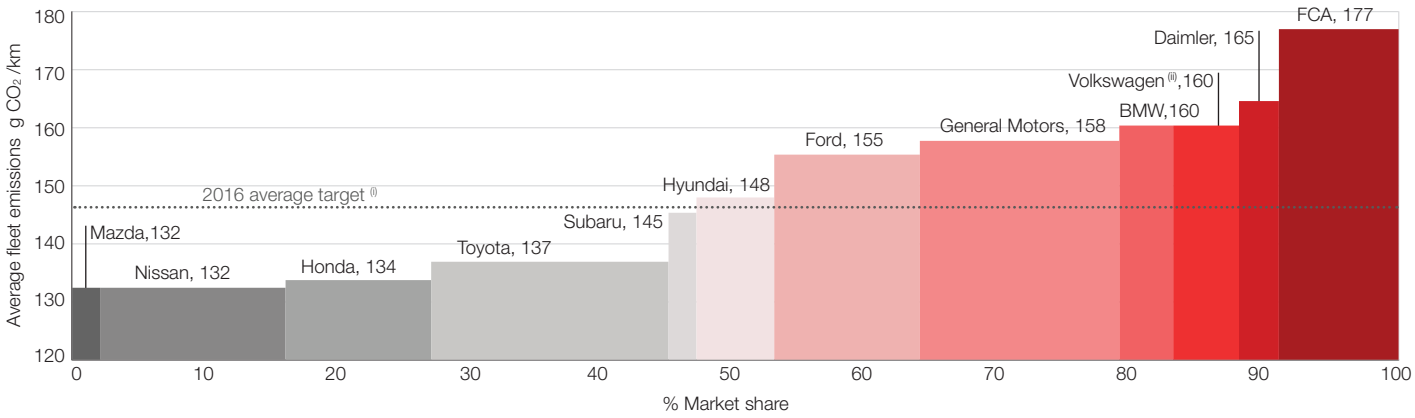
The US EPA's fleet-wide targets for 2021 are 173 gCO_2/mile for passenger vehicles and 250 gCO_2/mile for light trucks (equivalent to 119 gCO_2/km and 173 gCO_2/km respectively on the NEDC test cycle). Targets are adjusted to give a specific target for each OEM according to its fleet average "footprint" (related to the size of a vehicle).

We acknowledge that from a compliance perspective, when taking into account credits from prior model years, all OEMs in our study have reported adherence with the standards.[24] However, our study attempts to differentiate OEMs in US fleet emissions using the following key metrics:

Metric 1) Passenger vehicle (PV) performance
This metric focuses on the extent to which companies have reduced their PV fleet emissions over the period 2011 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2021 targets.[25]

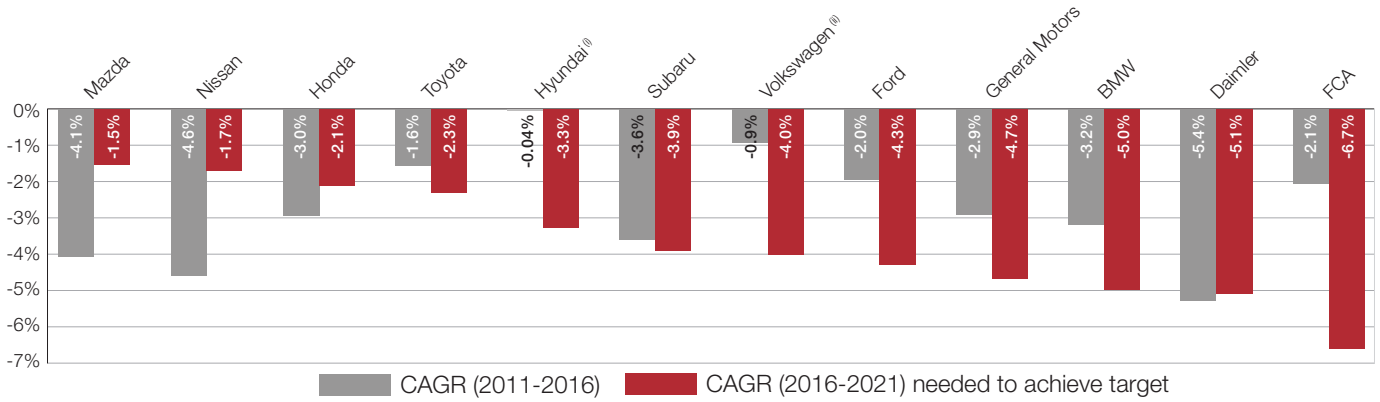
Metric 2) Truck performance
This metric focuses on the extent to which companies have reduced their truck fleet emissions over the period 2011 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2021 targets.

Figure 24: (US) Passenger vehicles: Average fleet emissions (2016)



(i) This is the company-wide fleet average target. Each OEM is assessed against its own specific target according to its fleet average footprint.
(ii) Due to emissions scandal Volkswagen has been ranked last for the US emissions section. Value shown is a combined value for passenger vehicles and trucks.
Source: CDP, company reports, US Environmental Protection Agency

Figure 25: (US) Passenger vehicles: Comparison of past progress and future performance needed to meet 2021 target



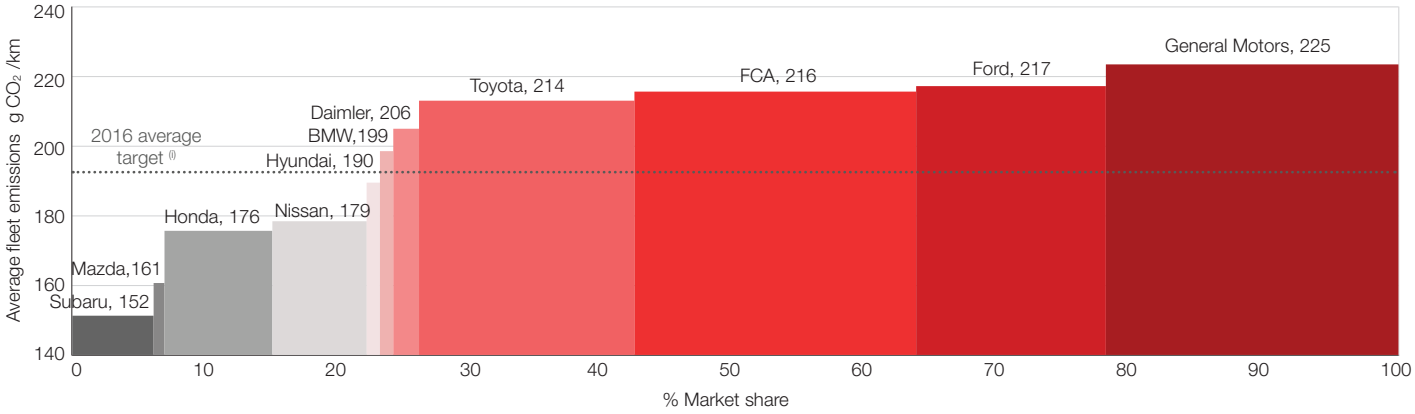
(i) Hyundai: CAGR (2013-2016) due to lack of data.
(ii) Due to emissions scandal Volkswagen has been ranked last for the US emissions section. Value shown is a combined value for passenger vehicles and trucks.
Source: CDP, company reports, US Environmental Protection Agency

24. OEM's with deficits in a model year may use credits to offset a deficit (credits can be purchased, traded and carried forward five years).
25. We note that 2016 data is preliminary and based on projected production data provided to EPA by OEMs. In addition, Tata Motors have circa 11% of sales in the US. However, total vehicle sales are below the 150,000 threshold for the standard emissions regulations to apply.

Highlights

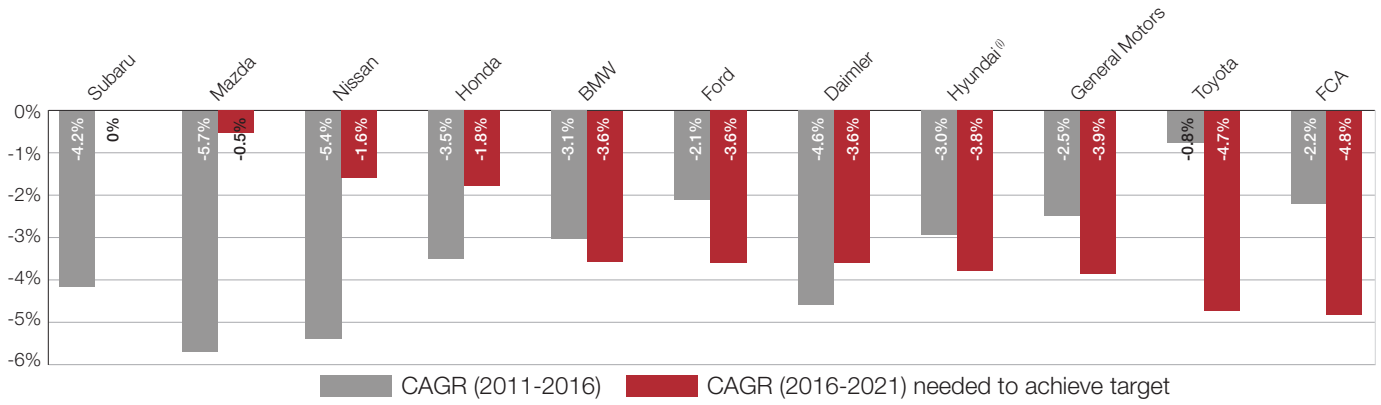
- OEMs will need to increase fleet emissions reduction rates for passenger vehicles (PVs) in order to meet 2021 targets. On average, for PVs, a reduction rate of 3.7% p.a. is required (compared to 3.0% p.a. achieved over 2011-2016). Things look better for trucks where a reduction rate of 2.9% p.a. is required compared to 3.4% achieved over 2011-2016.
- Mazda and Nissan both perform strongly having reduced historical fleet emissions for PVs and trucks significantly since 2011 and requiring some of the lowest reduction rates needed to meet their respective 2021 targets (Figures 25 & 27).
- FCA are the worst performer. Historical fleet emission reduction rates are low and much higher rates of emissions reduction are required to meet 2021 targets.
- We do not estimate any financial penalties for the US market in recognition that OEMs are able to generate and transfer / purchase compliance credits. Furthermore, it remains to be seen if the current yearly targets out to 2021 and 2025 remain in place with the ongoing reviews conducted by the EPA. However, we encourage investors to ensure companies strive towards meeting or exceeding fleet emission targets in accordance with a transition to a low-carbon economy.

Figure 26: (US) Trucks: Average fleet emissions (2016)



(i) This is the company-wide fleet average target. Each OEM is assessed against its own specific target according to its fleet average footprint.
Source: CDP, company reports, US Environmental Protection Agency

Figure 27: (US) Trucks: Comparison of past progress and future performance needed to meet 2021 target



(i) Hyundai: CAGR (2014-2016) due to lack of data.
Source: CDP, company reports, US Environmental Protection Agency

China fleet emissions

China is the largest vehicle market in the world, accounting for 29% of global light vehicle sales (28m light vehicle sales in 2016). All 16 companies in our study are exposed to the Chinese market, together representing a market share of 57%. OEMs mainly sell cars in China through forming joint ventures (JV) with Chinese OEMs and produce domestically (54% share of the Chinese market) but also export directly into China (3% share).

China's Corporate Average Fuel Consumption (CAFC) regulation uses the EU regulations as a template but with different hurdles and penalties. The industry fleet-wide targets for passenger vehicles are 5 L/100km for 2020 and 4 L/100km for 2025, which equate to 117 gCO_2/km and 93 gCO_2/km on the NEDC test cycle. These targets are adjusted for each OEM based on fleet average weight.

The regulatory agency, the Ministry of Industry and Information Technology (MIIT), announced that OEMs which fail to meet their targets will face the following penalties:

- Publicly named and shamed;
- A ban on the production of new models that do not meet their specific weight-based targets (by not issuing type-approval certification);
- Any proposed investment projects of plant expansion or new plants will not be approved.

We assess performance based on the following key metrics:

Metric 1) Joint venture (JV) passenger vehicle performance
This metric focuses on the extent to which companies have reduced their JV fleet fuel consumption over the period 2013 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2020 targets.

Metric 2) Imported passenger vehicle performance
This metric focuses on the extent to which companies have reduced their imported fleet fuel consumption over the period 2013 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2020 targets.

Highlights

- OEMs will need to significantly reduce fleet fuel consumption in order to meet 2020 targets. On average, for joint venture (JV) passenger vehicles, a 6.3% reduction p.a. is required (compared to 2.1% p.a. achieved over 2013-2016) and for imported vehicles an 8.2% reduction rate p.a. is required (compared to 3.2% p.a. achieved over 2013 – 2016). Tightening fuel consumption regulations in combination with NEV share mandates[26] present significant challenges to OEMs in the region.
- Referring to Figures 29-31 General Motors is a clear laggard. Its fleet fuel consumption for JV and imported vehicles is far above target levels, having increased fuel consumption levels over the 2013-2016 period.
- Daimler and BMW top the rankings. Daimler with its JV partner BAIC Motor reduced fleet fuel consumption the quickest (10% p.a.) and both BMW and Daimler require smaller reduction rates than most in order to meet the 2020 targets (Figures 30 & 31).

Real-world CO_2 emissions

Countries use different testing methods to regulate fleet CO_2 emissions i.e. NEDC for EU (which China follows), US combined cycles for US (which South Korea follows) and JC08 for Japan.

It is estimated that real-world CO_2 emissions are on average 30% higher for passenger vehicles (17% higher for vans) than the official lab-based data from the above testing regimes.[27]

In an effort to reduce this discrepancy, many regions will be implementing a new standardized testing procedure, the Worldwide Harmonized Light Vehicles Test Procedures (WLTP) over the coming years. The procedure includes more acceleration and deceleration, higher speeds and lasts longer (Figure 28).

OEMs not only face stricter emissions regulations in the future but also tougher testing procedures and must focus on implementing measures which reduce emissions under real-world driving conditions.

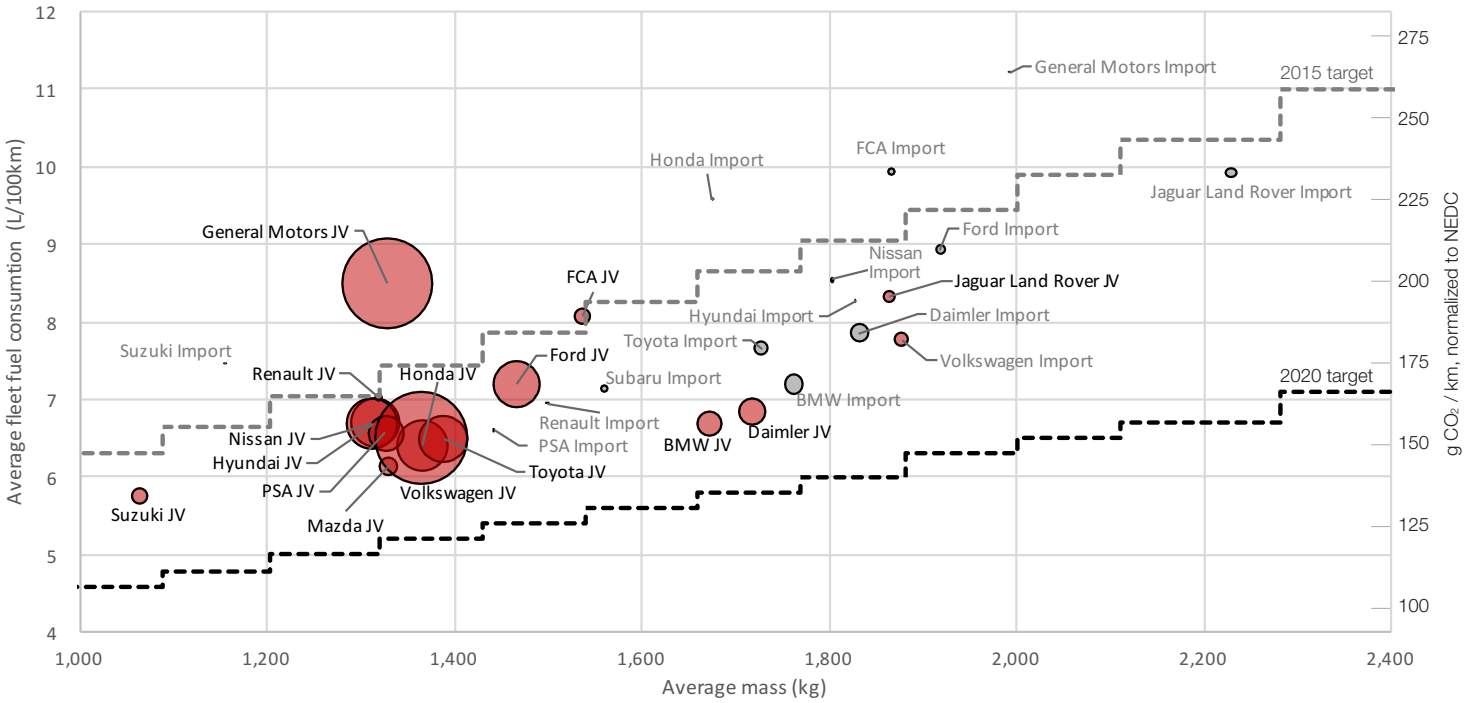
Figure 28: Driving cycles for NEDC and WLTP

	Units	NEDC	WLTP
Start condition		cold	cold
Duration	sec	1180	1800
Distance	km	11.03	23.27
Mean velocity	km/h	33.6	46.5
Max velocity	km/h	120.0	131.3
Stop phases		14	9
Durations:			
Stop	sec	280	226
Constant driving	sec	475	66
Acceleration	sec	247	789
Deceleration	sec	178	719

Source: ICCT

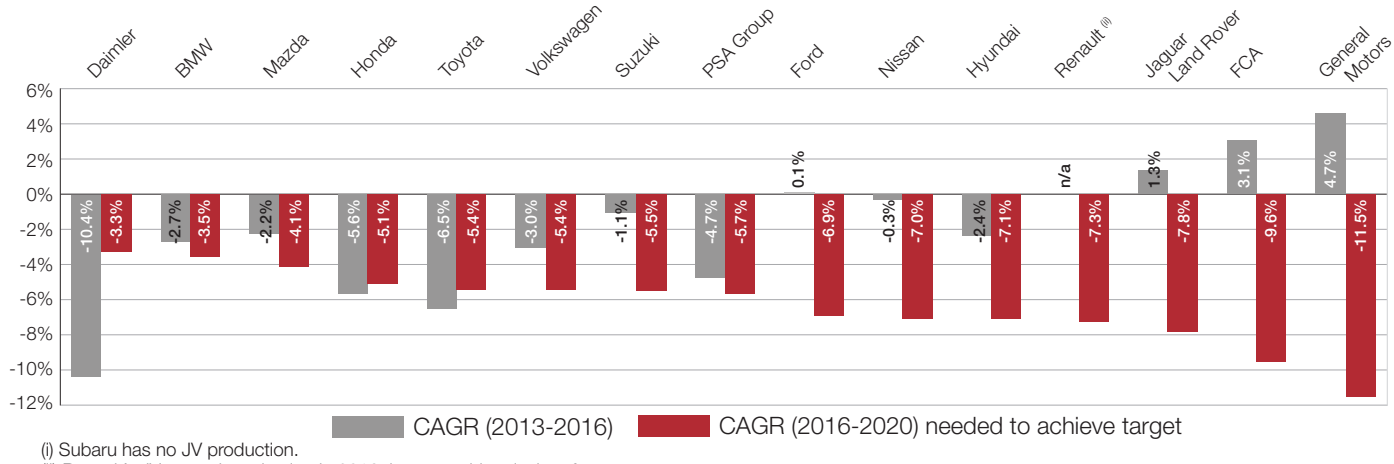
26. China has announced new energy vehicles (NEV) share mandates of 10% for 2019 and 12% for 2020 (though as long-range NEVs can receive up to five credits, mandatory shares are more like 2.5-3% in 2019 and 3.5-4% in 2020).
27. Equa Index, Emissions Analytics

Figure 29: (China) Passenger vehicles: Average fleet fuel consumption (2016) vs. vehicle weight and targets



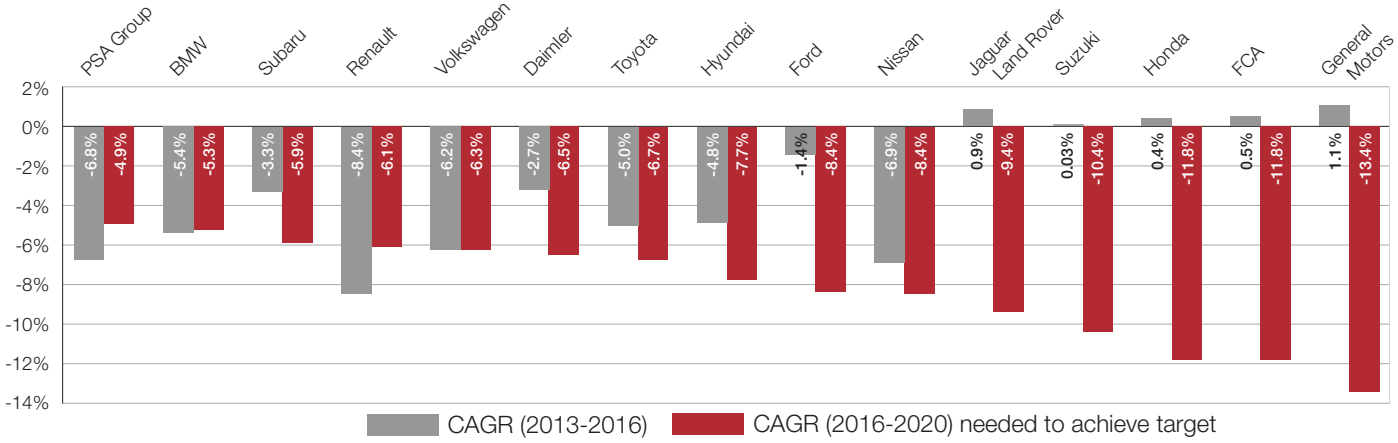
Bubble size = number of vehicle sales
Source: CDP, China's Ministry of Industry and Information Technology (MIIT)

Figure 30: (China JV) Passenger vehicles: Comparison of progress and future performance needed to meet 2020 target [i]



(i) Subaru has no JV production.
(ii) Renault's JV started production in 2016, hence no historical performance.
Source: CDP, China's Ministry of Industry and Information Technology (MIIT)

Figure 31: (China Imported) PV: Comparison of past progress and future performance needed to meet 2020 target [i]



(i) Mazda had no imports in 2016.
Source: CDP, China's Ministry of Industry and Information Technology (MIIT)

Japan fleet emissions

The six Japanese OEMs in our study represent a market share of 91%.[28] In this chapter we assess their historical performance and how they compare to the fuel economy target for 2020. The industry-wide fuel economy standard is 20.3 km/L (4.9L / 100km) for 2020 (measured under the JC08 test cycle), which equates to 115 gCO_2/km on the NEDC test cycle.

Under the Japan fuel economy regulation, each vehicle has its own target based on its weight category. The target value for each weight category is established based on the "best-in-class" fuel economy performance. According to the MLIT,[29] OEMs which fail to meet their targets will receive warnings, public naming and shaming and a fine of up to JP¥ 1 million (around US$ 8,900) per year.

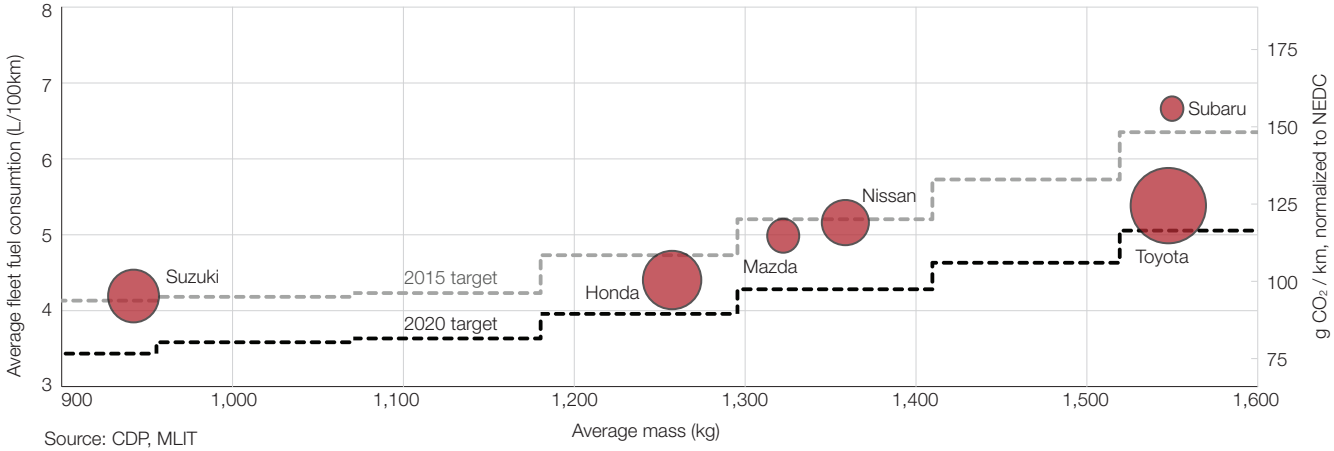
We identify leaders and laggards using the following metric:

Metric 1) Passenger vehicle (PV) performance
The metric focuses on the extent to which companies have reduced their PV fleet fuel consumption over the period 2012 – 2016 and identifies the annual reduction rate required for OEMs to meet their respective 2020 targets.

Highlights

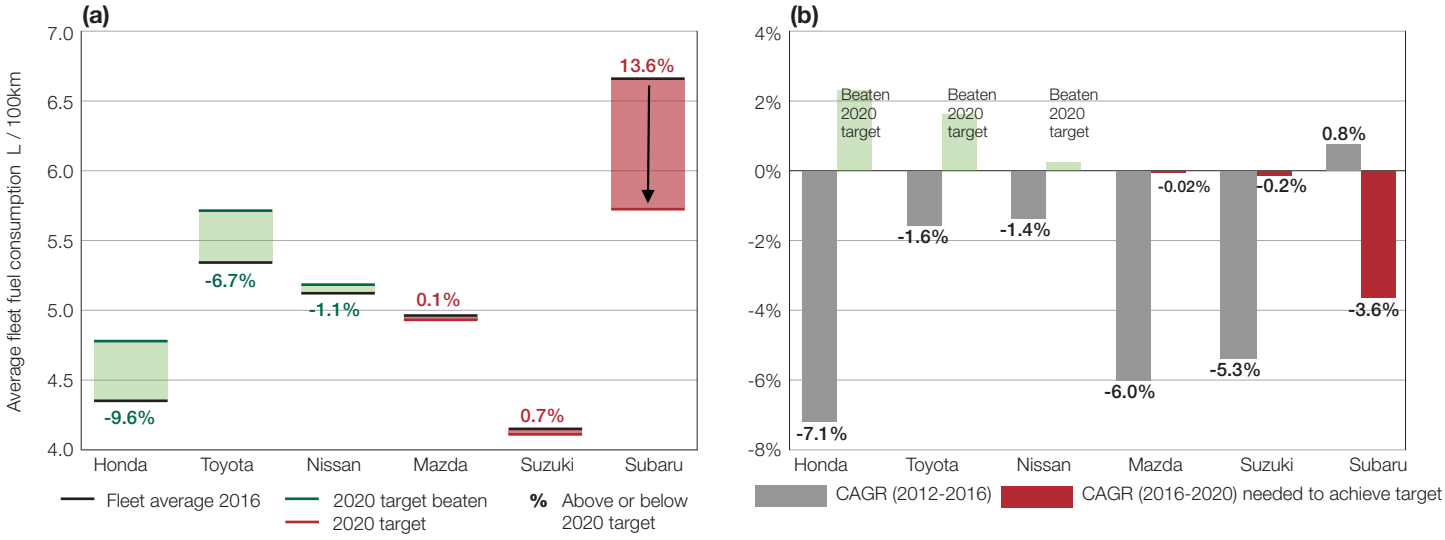
- Japan fleet performance beat the 2015 fuel economy target in 2011 and beat the 2020 fuel economy target in 2013. This historical performance shows that the Japanese passenger vehicle regulations could be more stringent and as shown in Figure 13(a) on page 11, the 2020 target lacks ambition compared to other country targets.
- As shown in Figure 33, Honda, Toyota and Nissan have already beaten their 2020 targets. (We also note that in 2015 Mazda also just beat their 2020 target.) Honda is a clear leader, having beaten their 2020 target by the largest margin and reduced fleet fuel consumption the most since 2012.
- Subaru is perhaps the only Japanese OEM that may struggle to meet its 2020 fuel economy target. Its average fleet fuel consumption increased over the 2012-2016 period and it requires a reduction rate of 3.6% p.a. in fleet fuel consumption in order to meet its 2020 target.

Figure 32: (Japan) Passenger vehicles: Average fleet fuel consumption (2016) vs. vehicle weight and targets



Source: CDP, MLIT

Figure 33: (Japan) Passenger vehicles: Comparison of current fuel consumption level (2016) and 2020 target level



Source: CDP, Ministry of Land, Infrastructure, Transport and Tourism

28. Some non-Japanese OEMs in our study also have exposure to the Japanese market but it is very limited. The total imports from non-Japanese OEMs account for less than 6% of the Japanese market.
29. The regulatory agency in Japan is the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Manufacturing emissions and energy intensity

OEMs' manufacturing emissions and energy intensity can serve as a good proxy for assessing manufacturing efficiency trends. Actions to reduce emissions and energy usage range from material substitution to waste heat recovery systems. From an operational cost perspective, these measures can yield significant cost savings and thus improved margins.

We identify leaders and laggards in manufacturing efficiency using the following metrics:

Metric 1) Emissions intensity performance: This metric focuses on the extent to which companies have reduced their operational emissions intensity over the period 2010-2016 and identifies the companies with the lowest current Scope 1+2 emissions intensity level. We use unit vehicle production to normalize emissions.

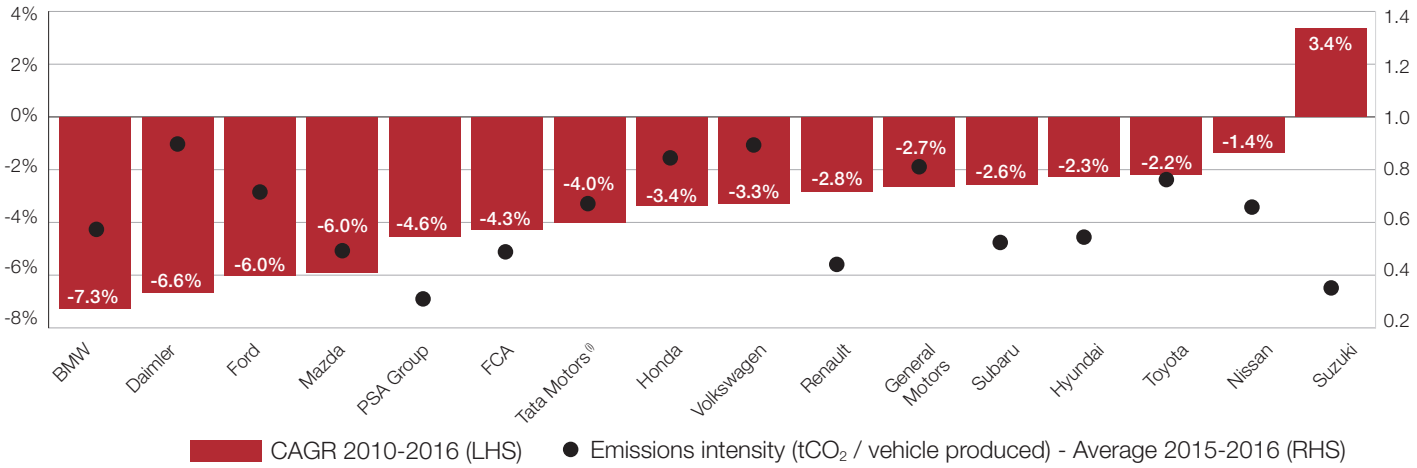
Metric 2) Energy intensity performance: This metric focuses on the extent to which companies have reduced their energy intensity over the period 2010-2016 and highlights the companies with the lowest current energy intensity per unit vehicle produced.

Highlights

- Only Suzuki has failed to reduce manufacturing emissions and energy intensity over the 2010 – 2016 period. However, it should be noted that Suzuki has both the second lowest emissions intensity (0.33 tCO_2 / vehicle produced) and energy intensity (1.2 MWh / vehicle produced).

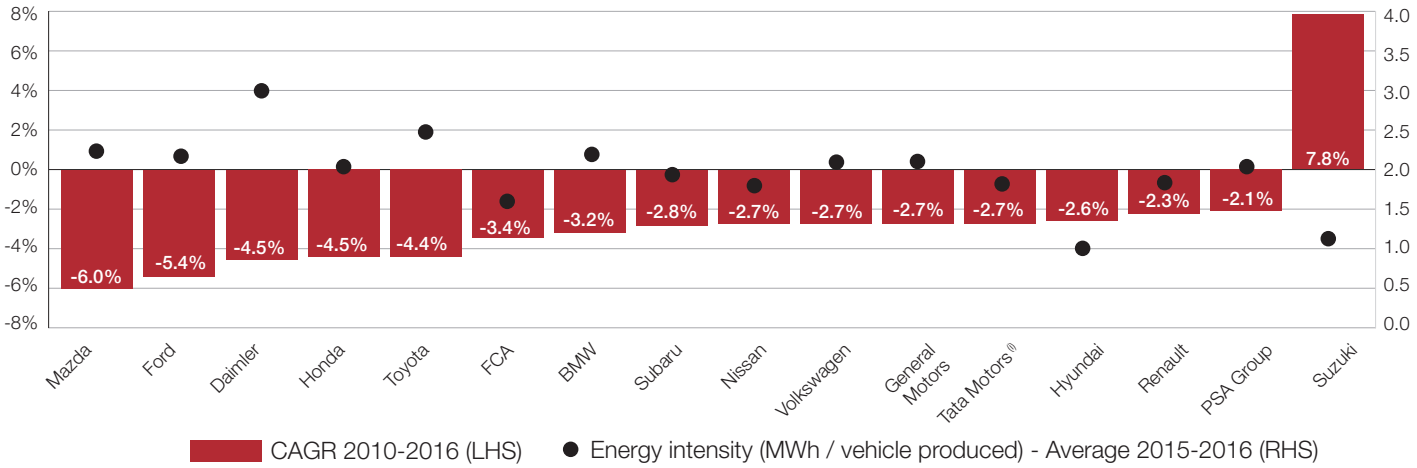
- Mazda ranks first with Ford a close second. Both companies have significantly reduced manufacturing emissions and energy intensity since 2010 as shown in Figures 34 & 35.

Figure 34: Emissions intensity



(i) Weighted average of Tata Motors Limited (TML) and Jaguar Land Rover (JLR) data. We note significant difference in performance: TML CAGR only -0.4% vs. -9.4% for JLR.
Source: CDP, company reports

Figure 35: Energy intensity



(i) Weighted average of Tata Motors Limited (TML) and Jaguar Land Rover (JLR) data. We note significant difference in performance: TML CAGR -2.5% vs. -9.5% for JLR.
Source: CDP, company reports

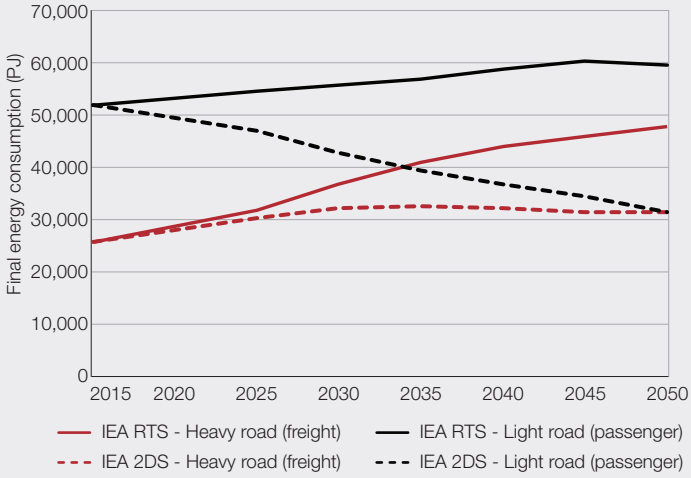
Electrons for 18-wheels

What can be the future of long-haul trucks in a brave new world of electrification and automation?

Although heavy truck pollutants such as Nitrogen Oxides (NO_x), Carbon Monoxide (CO) and Sulphur Dioxide (SO_2) have been regulated to a large extent across all major economies, GHG emissions are only regulated in Canada, Japan, China and the U.S. in some form. Lagging behind is the EU, which only recently proposed a certification system for CO_2 emissions for new vehicles and has plans to propose emissions standards in 2018.[30]

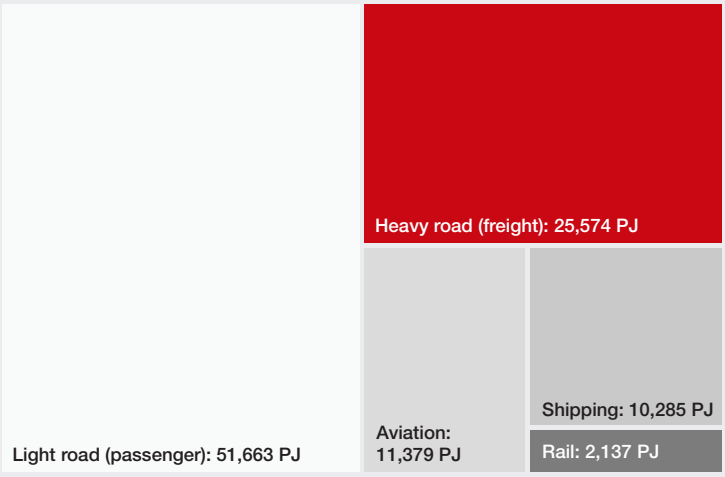
Heavy-duty trucks (HDT) and cargo vehicles in general have not received as much scrutiny as passenger vehicles regarding GHG emissions, which is demonstrated in the Nationally Determined Contributions provided by countries to the Paris Agreement. In this Reference Scenario (IEA RTS in Figure 36) heavy road freight fuel consumption is allowed to rise at a significantly higher rate than passenger vehicles out to 2050, whereas a 2-degree scenario requires that heavy freight fuel consumption levels out at around 32,000PJ by 2030. The lack of attention to more stringent CO_2 regulation may come as a surprise, considering that as a percentage of global GHG emissions, road transport accounts for 17% of global emissions. Within road transport, heavy and light road freight comprise 38% of final energy consumption.[31] Heavy road freight is the second largest energy consumer behind passenger vehicles and is more than shipping and aviation combined (Figure 37).

Figure 36: Road transport - final energy consumption scenarios



Source: IEA ETP 2017

Figure 37: Transport sector - current share of final energy consumption



Source: IEA ETP 2017

Energizing the market

The gap in emissions standards and the targets for a 2-degree transition could mean that a sudden regulatory squeeze takes effect in the near future, but even in the absence of immediate regulatory pressure some established truck manufacturers and new entrants to the market have been tentatively or fully embracing an electric truck future. HDTs, used for inter-city and long-haul routes, have been slower to catch on than urban electric trucks, but a flurry of activity in the past year has proven that vehicle manufacturers see the potential for growth. BYD, Mercedes-Benz Trucks (Daimler), and Man Trucks (Volkswagen) have all recently announced battery-electric long-haul truck prototypes. Furthermore, brand new entrants to the truck manufacturing business like Tesla and Cummins have also developed prototypes, and a variety of electric truck conversion companies have emerged to turn a conventional truck into a battery-electric vehicle.

Getting through the resistance

Are these and other truck companies foolishly following the crowd when it comes to electric vehicles or could the silent whine of electric motors soon ferry merchandise across countries? The challenges for an electric truck to overcome are similar to those for passenger vehicles but on a much larger scale. The incremental cost of a 400 mile range battery pack, for instance, on top of an otherwise conventional HDT could be close to $250,000 currently, but this is projected to decrease to $40,000 when battery costs fall.[32] However, even if battery costs decrease significantly, the energy density and weight of batteries and electric motors will need to decrease in tandem to ensure that an electric truck's load-hauling capacity does not diminish with a more affordable battery pack.

With larger battery packs, trucks will need to spend more time charging and would require higher-capacity charging infrastructure. For HDT's that spend most of their time on long journeys between cities, this infrastructure will need to be placed in rural areas where charging is currently very limited; even for passenger vehicles. This could be mitigated by service stations swapping freshly charged batteries for depleted ones, although this would demand a level of battery standardization that would be another obstacle for a fledgling industry. Other electrification opportunities for long-haul trucking include the electrification of highways through overhead wires or conductive plates underneath the road surface.

30. Europa, Reducing CO_2 emissions from heavy-duty-vehicles, https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en
31. IEA ETP 2017
32. The Future of Trucks – Implications for Energy and the Environment, IEA

If the challenges behind upfront cost, energy density, and charging infrastructure can be managed, full-electric HDTs can provide fleet operators with numerous advantages. Life-cycle GHG emissions per truck could be reduced by 80% when joined with renewable electricity.[33] In addition, fuel savings compared to a conventional HDT could equal between US$60,000- US$95,000 per year[34] and maintenance costs for electric trucks have been estimated to be less than conventional ones.

Electric minds for electric muscle

Although automation does not need to be limited to electric trucks, there seems to be a natural affinity between companies who are able and willing to create a pioneering electric vehicle and the software and systems necessary for safe and reliable autonomous trucking. Electric motors are well-suited to the split-second interventions and efficiencies that an autonomous system will use, and in trucking automation can be used to perform even more fuel saving techniques, such as platooning. In platooning, multiple trucks follow each other at a close distance to take advantage of a slipstream effect that significantly lowers drag, saving an additional 10% of CO_2 for conventional trucks, and a similar reduction in energy usage for an electric vehicle.[35] With this technique it might even be possible for a lead truck with a larger battery to recharge the other trucks en-route, effectively turning it into a modular road train. Other benefits through automation for trucks would include a higher rate of overnight driving, more accurate scheduling, and much lower labour costs. However, a higher utilization rate due to lower fuel and labour costs would mean that it is even more important that automation is coupled with electrified trucking if overall emissions are to be kept on a lower pathway.

Business resilience

Carmakers face two major disruptive technologies – electric vehicles and autonomous, shared driving. However, some areas of the automotive industry may be more resilient to disruption.

Much of the growth in the sector is expected to come from emerging markets.[36] ICE vehicles are likely to survive longer in these regions due to weaker emissions regulation and autonomous vehicles will struggle to cope with the chaotic city traffic which is often present. Of course these types of markets can also leapfrog developed markets in uptake of new technologies; however, timeframes are likely to differ. OEMs should keep abreast of long-term trends and look to leverage existing positions.

Other automotive areas such as trucks, motorbikes and machinery provide a level of diversification for companies and although we also expect to see the impact of new technologies affecting these business areas,[37] change is likely to take different forms and occur over different timescales. Companies also have the option to spin off non-core parts of the business which could unlock value if timed correctly. Luxury vehicle sales is another area that may prove more resilient due to higher profit margins and less price-sensitive customers.

As mentioned previously, companies need to increase sales of advanced vehicles in order to meet tightening emissions regulations. Transitioning to advanced vehicles will initially dilute OEM profit margins and with ICE compliance costs also set to increase, OEM's profits are being squeezed on both sides. Companies that operate with higher EBIT margins have more room to manoeuvre.

We identify which OEMs are potentially more resilient to disruptive forces using the following metrics:

Metric 1) Exposure to emerging markets
OEMs with higher sales exposure to emerging markets are ranked higher.

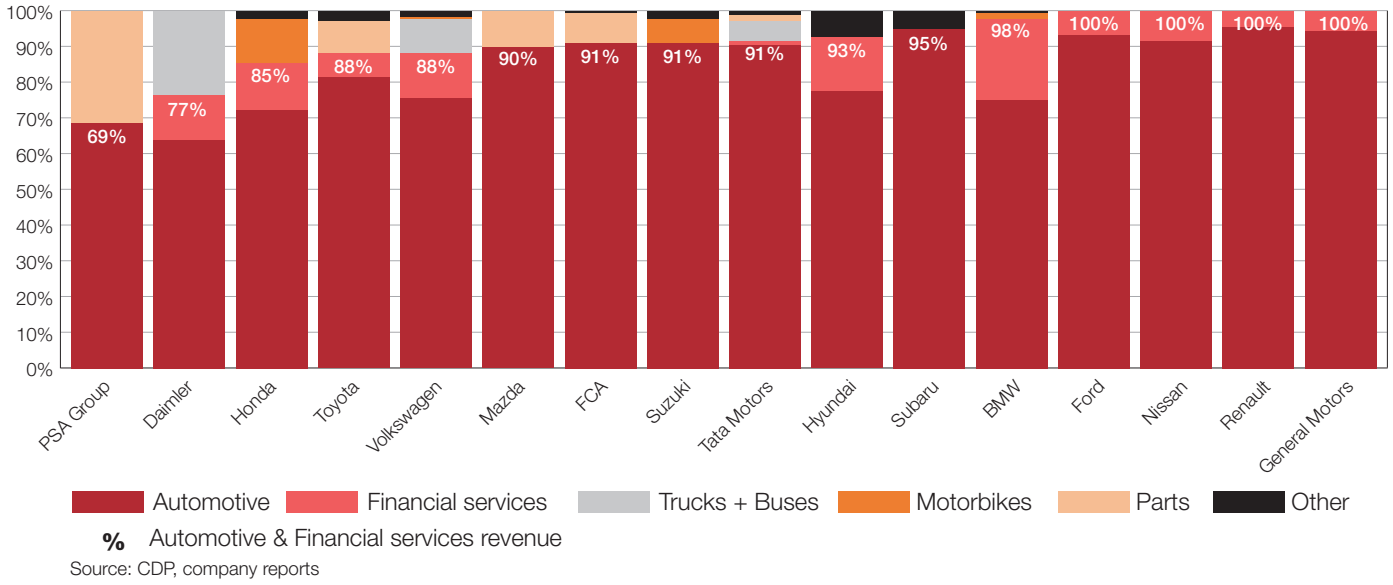
Metric 2) Diversification – share of non-automotive revenue
Companies are ranked based on the overall share of revenue coming from business areas that may suffer less disruptive change i.e. trucks & buses, motorbikes, parts and other areas such as machinery.

Metric 3) Share of sales from luxury vehicles
OEMs with a higher proportion of luxury sales are ranked higher (includes luxury sedans, limousines, super sports cars and large premium SUVs.)

Metric 4) EBIT margin
Companies are ranked based on their Adjusted EBIT margin over the period 2015 – Q3 2017.

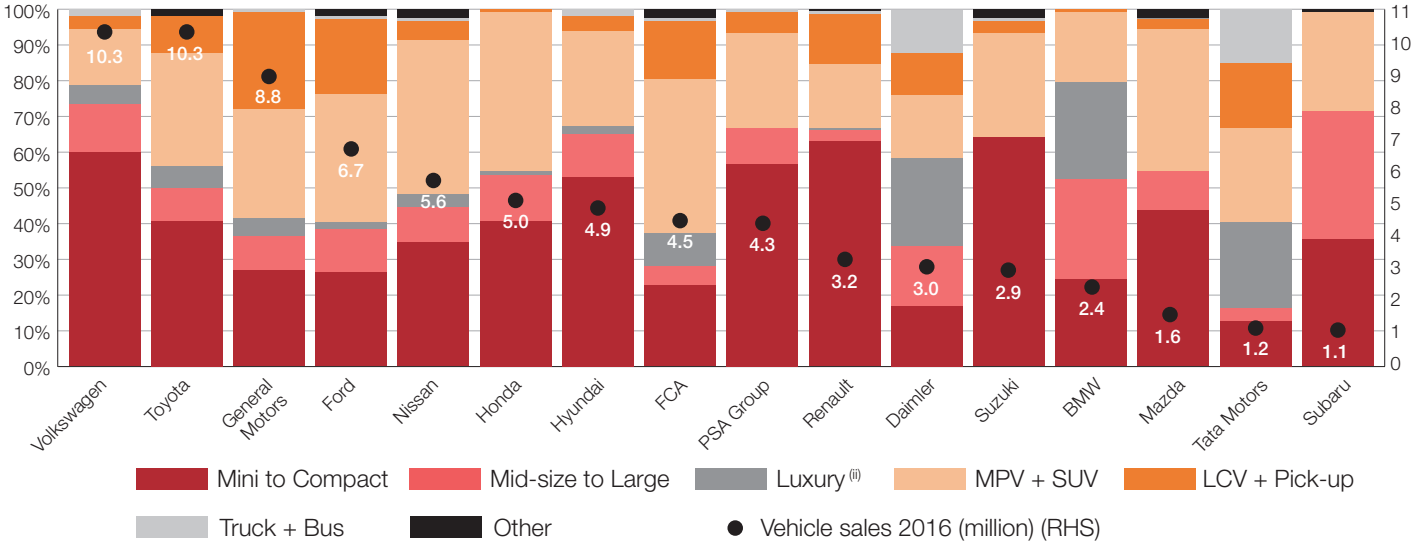
33. Transitioning to zero-emission heavy-duty freight vehicles, ICCT
34. The Future of Trucks – Implications for Energy and the Environment, IEA
35. http://www.acea.be/news/article/what-are-the-benefits-of-truck-platooning
36. Goldman Sachs forecast a 50% increase in vehicle sales in emerging markets compared to 8% decline in developed markets.
37. See box "Electrons for 18 wheels" above.

Figure 38: Revenue split by business (2016)



Source: CDP, company reports

Figure 39: Vehicle sales split by type (2016)[i]



(i) Excludes motorcycle sales.
(ii) Luxury category also includes large premium SUVs.
Source: CDP, company reports, Marklines, Bloomberg

Highlights

- Figure 3 on page 4 shows vehicle sales split by region. With high sales in emerging markets such as India, Suzuki, Tata Motors, Renault and Hyundai could be well placed to take advantage of the expected growth in these regions.

- Daimler ranks first across the four metrics. It is the world's largest truck manufacturer (with trucks & buses contributing to 23% of group revenue in 2016, see Figure 38), has a high share of luxury vehicle sales (Figure 39) and a relatively high EBIT margin (9.1% over the period 2015 – Q3 2017), all of which may help the company to be more resilient to disruptive change.

- Toyota and Tata Motors rank second and third respectively. Toyota performs consistently well across the four metrics while Tata Motors has good exposure to emerging markets (primarily India), a trucks business and a high share of luxury vehicles from its Jaguar Land Rover models.

- Ford ranks last. It lacks diversification, with all of group revenue coming from automotive / financial services[38] (see Figure 38). It has a relatively low share of luxury vehicles and lower exposure than most to emerging markets. Its EBIT margin is also amongst the lowest (Figure 40).

Figure 40: EBIT margin

Company	EBIT margin (2015 - Q3 2017)
Subaru	13.7%
BMW	10.0%
Daimler	9.1%
Toyota	8.3%
Suzuki	7.9%
Volkswagen	7.4%
Tata Motors	6.5%
FCA	6.4%
General Motors	6.1%
Renault	6.1%
Hyundai	5.8%
Nissan	5.8%
PSA Group	5.4%
Mazda	4.9%
Ford	4.7%
Honda	4.5%

Source: CDP, company reports

38. We consider financial services to be closely linked to the automotive business and therefore do not count it as diversification.

Transition opportunities

- General Motors is ranked first. It is working towards an “all-electric future”, has ambitious automation targets, and is investing heavily in the areas of autonomous vehicles and ride-sharing services.
- Volkswagen and BMW rank second and third respectively. Both companies have relatively aggressive advanced vehicle targets and have had success road-testing autonomous driving vehicles (ADVs).
- Subaru, Mazda and Suzuki make up the bottom three. With comparatively little activity in the areas of advanced vehicles, ADVs and mobility as a service (MaaS), the companies seem to have more of a ‘wait and see’ approach.

Overview

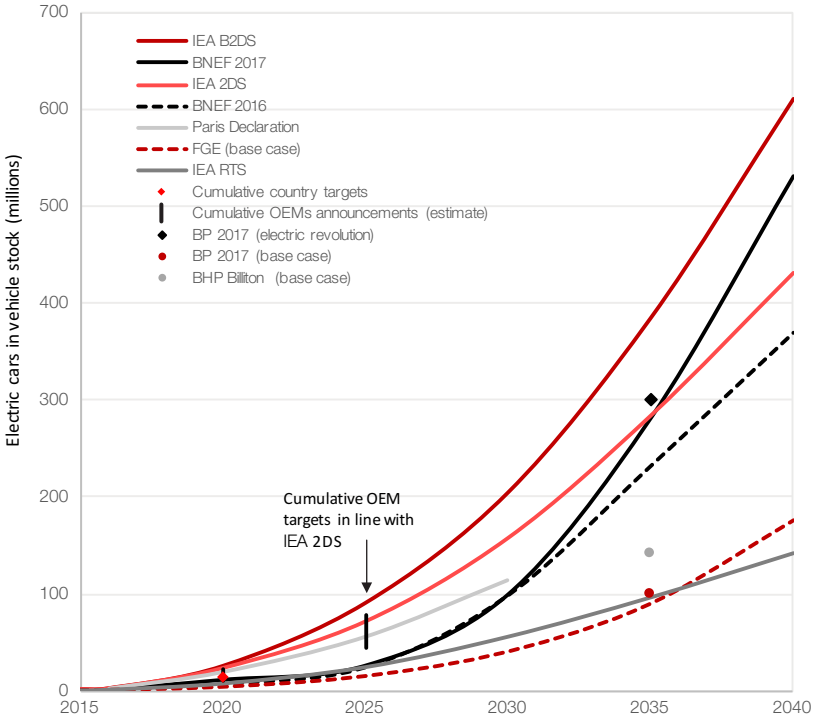
The automotive sector is in significant transition and on the edge of two waves of technological disruption - the first from electric vehicles and the second from autonomous, shared driving. Incumbent OEMs may see these challenges as threats to existing business models but to be successful they must embrace the new opportunities and markets that will become available over the coming years.

Figure 41 illustrates deployment scenarios for electric vehicles (EVs), with BNEF projecting 54% of new car sales to be electric by 2040. Li-ion battery prices continue to fall and we expect to see price parity with internal combustion engine (ICE) vehicles from around 2022.

A whole new ecosystem is emerging; integrating energy generation, storage and transport and the rise of autonomous driving vehicles (ADVs) and mobility as a service (MaaS) will fundamentally change the form and function of the sector.

In this section we assess the extent to which companies are capturing these transition opportunities across the following areas:

Figure 41: Deployment scenarios for electric cars to 2040



Source: IEA Global EV Outlook 2017, BNEF NEO 2016/17, FGE, BP Energy Outlook 2017

Advanced vehicles: We assess OEMs across a range of metrics: looking at market shares of advanced vehicle technologies, technical reviews of specific models, company targets, and patents filed by the OEMs.

Autonomous driving vehicles (ADVs) & mobility as a service (MaaS): We differentiate between leaders and laggards by assessing investment, acquisitions and partnerships relating to ADVs and MaaS, as well as automation targets, patents filed and ADV testing.

Research & development (R&D): We rank companies on their R&D expense to sales ratio over the period 2014 – 2016.

Renewable energy: We look at how companies are meeting their energy needs and rank them based on their renewable share of total energy use, renewable targets and membership of RE100.[39]

39. The RE100 initiative is a collaborative, global initiative of influential businesses committed to 100% renewable electricity: http://there100.org/

Figure 42: Transition opportunities summary

Company	Advanced vehicles	ADVs & MaaS	R&D	Renewable energy	Overall weighted rank	Transition opportunities rank
General Motors	7	1	5	7	5.7	1
Volkswagen	8	3	1	6	6.2	2
BMW	4	6	3	2	6.3	3
Nissan	3	4	9	11	6.7	4
Daimler	6	5	7	8	6.8	5
Ford	9	2	6	5	6.8	6
Hyundai	5	7	16	13	7.7	7
Toyota	1	9	12	12	7.7	8
Honda	2	10	4	10	7.8	9
Renault	10	8	8	4	8.6	10
Tata Motors (i)	12	12	2	1	9.8	11
PSA Group	11	11	10	9	10.1	12
FCA	13	13	15	3	11.3	13
Subaru	15	14	14	14	12.1	14
Mazda	16	15	13	15	12.3	15
Suzuki	14	16	11	16	12.5	16
Weighting	**50%**	**40%**	**5%**	**5%**		

(i) Analysis for Tata Motors includes fully owned subsidiary Jaguar Land Rover.

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

The rise of electric vehicles

The rise of electric vehicles (EVs) has been set in motion. Stricter emissions regulation, rising ICE CO_2 compliance costs, rising pollution levels, EV country quotas, OEM targets, falling battery costs and comparatively lower EV maintenance costs, all point to an electric future.

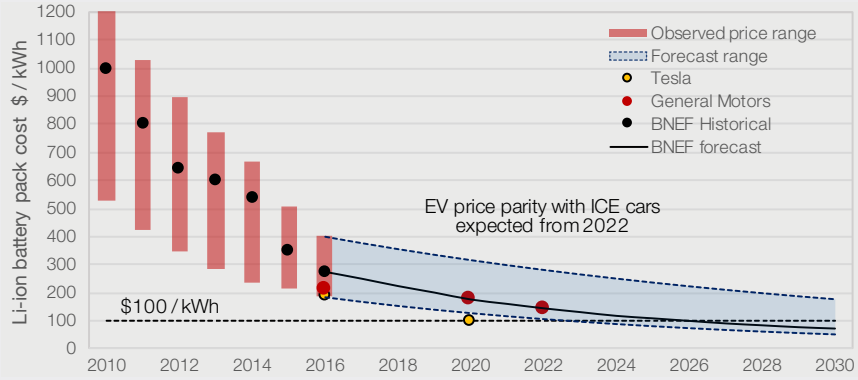
Currently, almost half the cost of a battery-electric vehicle (BEV) is due to the battery (Figure 44). With Li-ion battery pack costs continuing to fall (Figure 43), we expect to see price parity with ICE vehicles from around 2022.

Furthermore, with fewer parts (circa 11,000 compared to 30,000 for ICE vehicles)[40] EVs are cheaper to maintain and are seen to become the car of choice for autonomous driving vehicle fleets providing MaaS. (One estimate that looks at the US market sees the relative costs per mile at US$ 0.38 / mile for autonomous ICEs vs. only US$ 0.16 / mile for autonomous EVs.)[41]

2017 has seen some ambitious OEM EV target announcements and countries continue to ratchet up their support for the technology[42] – most notably China. The 'Made in China 2025' strategy targets 2 million new energy vehicle (NEV)[43] sales by 2020 and 7 million sales by 2025. China has also announced aggressive NEV share mandates of 10% for 2019 and 12% for 2020 (though as long-range NEVs can receive up to five credits, mandatory shares are more like 2.5-3% in 2019 and 3.5-4% in 2020).

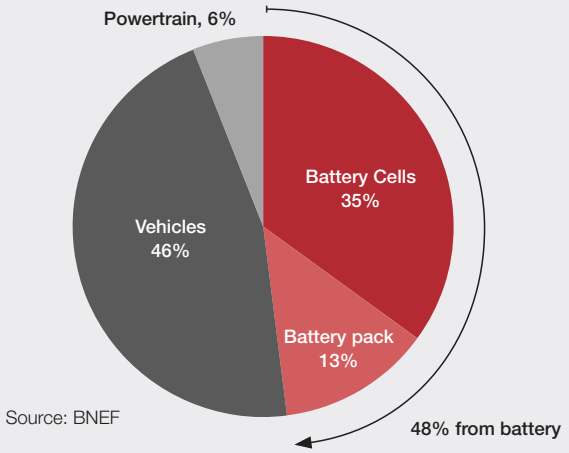
New technologies are gaining momentum and with initiatives such as EV100[44], the transition to electric vehicles is accelerating. Even under the most conservative estimates the expected growth will have dramatic consequences for other sectors – profoundly impacting the demand for certain commodities and altering energy systems.[45]

Figure 43: Li-ion battery pack cost reduction



Source: CDP, company reports, BNEF, EIA, BP, IEA, McKinsey

Figure 44: Cost breakdown for medium BEV (2016)



Source: BNEF

40. Cars-2025, Goldman Sachs
41. Rethinking Transportation 2020-2030, RethinkX
42. See summary table of country policy support for EVs on page 48.
43. China uses NEV as a term that encompasses PHEVs and BEVs.
44. EV100 is a global initiative bringing together companies committed to accelerating the transition to electric vehicles.
45. For further discussion see our Mining, Utilities and Oil & gas sector reports.

Advanced vehicles

Advanced vehicles such as fuel cell vehicles (FCVs), battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) are game-changing technologies for the auto industry. In 2017 global EV sales surpassed one million for the first time - the industry is at a tipping point with technological disruption immanent.

2017 saw a profusion of company targets surrounding electric vehicles with various degrees of ambition. In a scenario where 30% of new cars sales are zero emission or plug-in hybrid by 2030, the potential market could add up to USD$1 trillion. The race is on to capture market share.

In this chapter, we differentiate the extent OEMs are capturing the advanced vehicle market using four key metrics:

Metric 1) Market share ratio: This metric compares OEM global market shares for each advanced vehicle technology to their market share for all vehicles. If the market share ratio is greater than 1.0 it indicates that a company's market share of that particular technology is greater than their share of the total vehicle market and implies that the OEM is pursuing a low-carbon strategy.[46]

Metric 2) Technical review: We assess models of FCVs, BEVs and PHEVs, available globally, based on a number of parameters: cost relative to vehicles in the same segment, electric range and efficiency (e.g. MPG-equivalent).

Metric 3) Advanced vehicle targets: We look at company targets for advanced vehicles, assessing levels of ambition based on the type of target, volume of sales and target year.

Metric 4) Patents filed: We identify companies that are leading by innovation and look at patents filed in the areas of fuel cell, electric and hybrid vehicles as well as Li-ion batteries for vehicles.

Figure 45: Advanced vehicles summary

Company	Market share ratio	Technical review	Advanced vehicle targets	Patents filed	Overall weighted rank	Advanced vehicles rank
Toyota	1	3	7	2	6.0	1
Honda	5	2	11	3	6.4	2
Nissan	3	9	8	1	7.1	3
BMW	2	8	3	9	7.1	4
Hyundai	6	1	12	4	7.1	5
Daimler	4	7	2	11	7.3	6
General Motors	8	4	5	6	7.4	7
Volkswagen	10	5	1	14	7.6	8
Ford	7	6	8	8	8.8	9
Renault	9	11	8	10	10.1	10
PSA Group	12	12	6	16	10.3	11
Tata Motors	16	14	4	12	10.3	12
FCA	11	10	13	15	11.5	13
Suzuki	13	16	14	5	12.0	14
Subaru	14	15	14	7	12.1	15
Mazda	15	13	14	13	12.4	16
Weighting	**30%**	**25%**	**25%**	**20%**		

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area. We display non-weighted ranks in this summary for simplicity only.

Source: CDP

46. This metric was first introduced by the ACT project (Assessing low-carbon transition), in which CDP partners with ADEME and others to develop ways to assess how ready organizations are to transition to a low-carbon world. http://actproject.net/

Highlights

Figures 46 to 49 illustrate advanced vehicle market share ratios over time and in total over the period 2010 – Q3 2017. Very few OEMs have produced market ready fuel cell vehicles (FCVs) and only Toyota and Honda have ratios above one, demonstrating market dominance in this technology (but it remains to be seen if the technology can be deployed at scale).

Figure 46: FCV market share / Total market share

Company	2010-Q3 2017
Toyota	7.76
Honda	2.45
Hyundai	0.68
Daimler	0.17

Source: CDP, company reports

Figure 47: BEV market share / Total market share

Company	2010-Q3 2017
Nissan	4.21
BMW	2.39
Renault	1.63
Daimler	0.76
PSA	0.36
Hyundai	0.22
Volkswagen	0.18
FCA	0.15
General Motors	0.15
Ford	0.07
Suzuki	0.04
Honda	0.02
Toyota	0.01

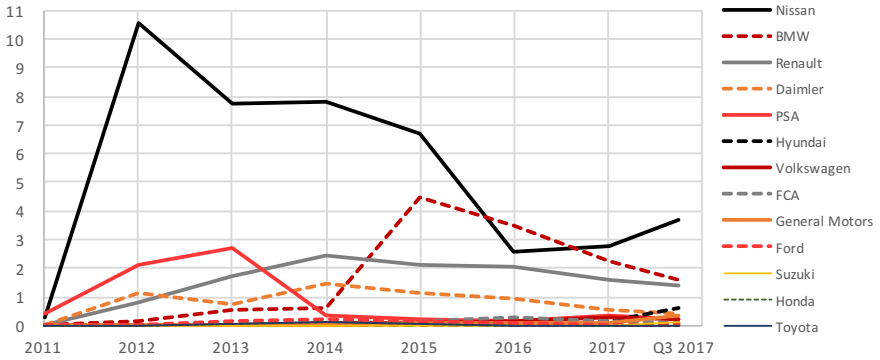


Figure 48: PHEV market share / Total market share

Company	2010-Q3 2017
BMW	3.75
General Motors	1.51
Ford	1.42
Daimler	1.35
Toyota	1.07
Volkswagen	0.95
Hyundai	0.12
FCA	0.04
Honda	0.03

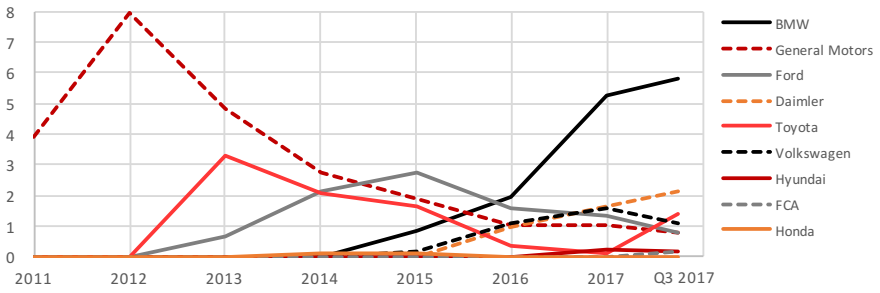
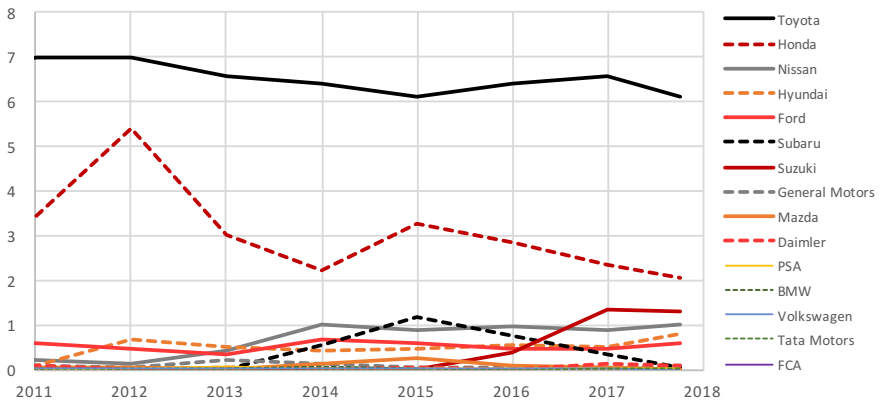


Figure 49: HEV market share / Total market share

Company	2010-Q3 2017
Toyota	6.48
Honda	2.87
Nissan	0.78
Hyundai	0.51
Ford	0.51
Subaru	0.44
Suzuki	0.43
General Motors	0.09
Mazda	0.08
Daimler	0.05
PSA	0.02
BMW	0.02
Volkswagen	0.02
Tata Motors	0.004
FCA	0.0003



Source: CDP, company reports, Marklines, Bloomberg

- For BEVs, Nissan, BMW and Renault have ratios greater than one for the total period, primarily due to successful sales of the Nissan Leaf, Renault Zoe and BMW i3 models. Other OEMs have had ratios above one for certain years but have struggled to keep pace with the market. Hyundai, with its Ioniq Electric, is a later entry but is starting to gain ground.

- Five OEMs have a ratio greater than one for PHEVs, with BMW currently in a dominant position in terms of relative market share. General Motors is in second place overall due to its success with the Chevrolet Volt but has not maintained its early lead in the technology.

- From Figure 49 it is clear that the hybrid market is more mature and it is no surprise that Toyota comes out on top due to its success with the Prius (which was first launched in 1997).

- The Hyundai Ioniq Electric achieves the top technical rank for BEVs. As shown in Figure 52 it has the best efficiency (15.4 kWh / 100km) and is competitive on both price and range. The Nissan Leaf (2018 model) ranks a close second but is let down slightly by its electrical efficiency. Figure 51 displays BEV model price vs. range – many planned future models are claiming ranges in excess of 500km, potentially eradicating range anxiety. A notable entry to the market is the I-Pace, Jaguar Land Rover's first BEV, which looks set to challenge the Tesla Model X.

- For FCVs, Toyota, Honda and Hyundai lead the market with Daimler picking up fourth place (Figure 50). More recently other OEMs have begun to dust off their research in this technology, including Volkswagen, BMW and most notably General Motor's partnership with Honda which looks to manufacture key components for FCVs at a factory in Michigan.

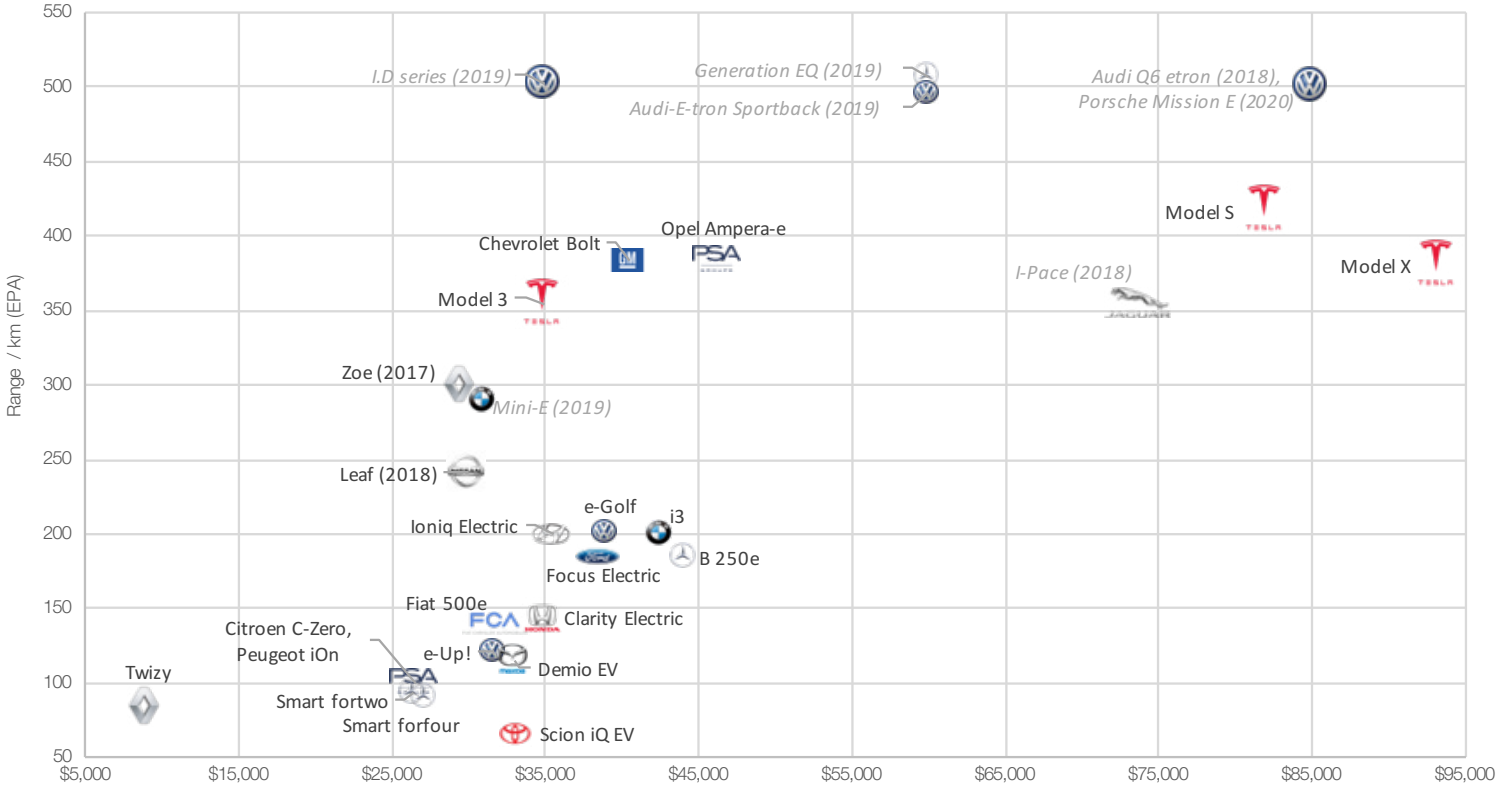
- Strong performers for PHEVs include the Honda Clarity, Hyundai Ioniq and the Chevrolet Volt (Figure 54). We note that Subaru, Mazda and PSA Group are all planning launches of their first PHEVs over the next few years (Figure 53).

Figure 50: Technical review FCV

Model	Year	Lease price ($ / month)	km / kg H2 (EPA)	Range / km (EPA)
Honda Clarity	2017	369	108	589
Toyota Mirai	2017	349	106	502
Hyundai ix35	2017	499	79	426
Mercedes B class F-CELL	2010 - 2014	850	85	310

Source: company reports, Marklines, US DoE

Figure 51: Price vs. range (BEV)



Source: company reports, Marklines, US DoE

Figure 52: Efficiency (BEV)

Model	kWh / 100km (EPA)
Hyundai Ioniq Electric	15.4
Volkswagen e-up!	15.7
Tesla Model 3	16.6
BMW i3	16.9
Toyota Scion iQ EV	17.3
Renault Zoe (2017)	17.6
Volkswagen e-Golf	17.6
Chevrolet Bolt	17.6
Volkswagen e-Golf	17.6
Opel Ampera-e	17.6
Honda Clarity	18.4
Nissan Leaf (2018)	18.7
Mazda Demio EV	18.7
Citroen C-Zero, Peugeot iOn	18.7
Fiat 500e	18.7
Smart fortwo	19.4
Ford Focus Electric	19.6
Smart forfour	19.7
Tesla Model S	20.1
Tesla Model X	22.5
Mercedes B 250e	24.9

Source: company reports, Marklines, US DoE

Figure 53: Additional models for release

Model	Type	Year	Range (km)	Price (USD)
Tata Motors - Tigor	BEV	2018	-	-
Fiat - Doblo	BEV	2019	-	-
Mazda - Unknown model	BEV	2019	-	-
Toyota - Aygo	BEV	2019	-	-
Ford - SUV	BEV	2020	483	-
Suzuki - Unknown model	BEV	2020	-	-
Subaru - variants of existing models	BEV	2021	-	-
Subaru - Unknown model	PHEV	2018	-	-
Peugeot - DS7 Crossback	PHEV	2019	-	66,500
Mazda - Unknown model	PHEV	2021	-	-

Source: company reports, Marklines

Figure 54: Technical review PHEV

PHEV Model	Year	Retail Price	MPGe (EPA)	EV only range / km (EPA)
BMW - i3 REX	2018	$48,300	111	156
General Motors - Chevrolet Volt	2018	$37,965	106	85
Honda - Clarity	2018	$33,400	110	77
Audi - Q7 e-tron quattro (i)	2017	$94,185	157	56
FCA - Pacifica Hybrid	2018	$41,995	84	53
Volkswagen - Passat GTE (i)	2017	$49,499	157	50
General Motors - Cadillac CT6	2018	$79,458	62	50
Land Rover - Range Rover Sport P400e (i)	2018	$80,613	101	50
Hyundai - Ioniq	2018	$30,766	119	47
Hyundai - Sonata	2017	$34,600	99	43
BMW - X1 xDrive 25Le iPerformance	2017	$59,820	66	40
Toyota - Prius PHV/Prime	2017	$34,245	133	40
Daimler - GLC 350e 4MATIC (i)	2016	$68,811	151	34
Ford - Fusion Energi	2018	$31,120	97	34
Daimler - E350e (i)	2017	$69,885	134	33
Ford - C-Max Energi	2017	$32,920	95	32
Volkswagen - A3 Sportback e-tron	2018	$48,211	83	26
BMW - 530e/540e iPerformance	2018	$60,495	72	26
BMW - i8	2017	$154,749	76	24
BMW - 740e/Le iPerformance	2018	$99,832	64	23
BMW - 330e iPerformance	2018	$48,387	71	23
BMW - X5 xDrive40e iPerformance	2018	$100,268	56	23
BMW - Mini Cooper S E Countryman ALL4	2018	$42,705	65	19
Daimler - GLE500/550e 4MATIC	2016	$69,679	43	16

(i) The NEDC figures have been quoted for these models where EPA figures were unavailable.
Source: company reports, Marklines, US DoE

Figure 55: Advanced vehicle targets

Company	Rank	Target Type	Target Year	% of sales	Comment
Volkswagen	1	BEV	2025 2030	25%	25% of global sales from BEVs. "Roadmap E" initiative - 80 new electric vehicles by 2025 (50 BEV, 30 PHEV). Spending €34 bn by end of 2022 on industrialization of e-mobility. Electric versions available on all 300 group models.
Daimler	2	BEV	2025	25%	25% of Mercedes sales from BEVs. (Investing €10bn in EV development. Smart to be fully electric line by 2020. Electric versions of all Mercedes cars by 2022).
BMW	3	BEV / PHEV	2025	15 - 25%	15 - 25% of group sales from BEVs and PHEVs. 25 electrified vehicles (12 fully electric).
Jaguar Land Rover (i)	4	BEV / PHEV / HEV	2020		Every vehicle launched from 2020 will be electrified. Launch of first BEV (Jaguar I-Pace) second half of 2018.
PSA Group	5	BEV / PHEV / HEV BEV / PHEV / HEV	2019 2025		Each new vehicle to have electrified version from 2019. To offer electrified version on all models by 2025 (launching 40 new electrified models).
General Motors	6	BEV / PHEV BEV / FCV BEV / FCV	2020 2023 2026	 ~ 15% (ii)	Annual sales of new energy vehicles (NEVs) of 150,000 units in China by 2020. (500,000 units by 2025). 20 new zero-emission electric vehicles by 2023 (including FCVs). Aims to sell 1 million electric vehicles by 2026.
Toyota	7	PHEV / HEV / FCV BEV / PHEV / HEV / FCV BEV / PHEV / HEV / FCV	2020 2025 2030	~ 15% (ii) ~ 50% (ii)	Targets annual sales of 1.5 million hybrids and 30,000 FCVs by 2020. Aims to commercialize solid state battery technology in early 2020s. Every model to be offered with an electrified option by 2025. More than 10 BEV models available worldwide by early 2020s. Sales of more than 5.5 million electrified vehicles (of which more than 1 million BEV / FCV - circa 9% of sales).
Ford	8	BEV / PHEV / HEV BEV / PHEV BEV / PHEV / HEV	2020 2022 2025	10%	10% of group sales from electric and hybrid vehicles. 40 electrified models (16 BEV models). Plans to invest $11 bn by 2022. 70% of sales in China to be electric or hybrid.
Renault	8	BEV / PHEV / HEV	2022		Electrified offer on > 60% of range. 20% of line-up BEVs (8 BEV models).
Nissan	8	BEV / FCV *BEV / FCV*	2020 *2022*	20%	Up to 20% of European sales from zero emissions vehicles. *Renault-Nissan-Mitsubishi alliance will launch 12 new zero-emission electric vehicles by 2022.*
Honda	11	BEV / PHEV / HEV / FCV	2030	67%	2/3 of total sales to be electrified by 2030. (15% of sales from BEV, PHEV and FCV).
Hyundai	12	BEV / PHEV / HEV / FCV	2020		Increase electrified models from 11 to 31 (includes 8 BEVs and 2 FCVs) by 2020.
FCA	13	BEV / PHEV / HEV	2022		Plans for more than 50% of fleet to be electrified by 2022. All Maserati models to be electrified from 2019. Plans are to be clarified H1 2018.
Subaru	14		2018		Plans to launch PHEV model version end of 2018 and BEV in 2021.
Mazda	14		2019		BEV to be launched in 2019 and PHEV in 2021. (Partnership with Toyota to develop EV technology).
Suzuki	14		2020		Current portfolio includes hybrids and BEVs to be launched in India by Maruti Suzuki in around 2020.
Tesla		*BEV*	*2020*		*Aiming for 1 million BEV unit sales.*

(i) Jaguar Land Rover is a fully owned subsidiary of Tata Motors (accounting for around 52% unit sales in 2016). No specific sales targets for EVs / Hybrids were found for Tata Motors but it is supplying 10,000 EVs to the Indian government and also plans to roll out electric busses and trucks.
(ii) Estimated value.
Source: CDP, company reports

- 2017 has seen a profusion of target announcements for advanced vehicles with most OEMs jumping on the bandwagon. Figure 55 summarises and ranks the targets in terms of ambition. We find Volkswagen's target to be the most aggressive which sees up to 25% of global sales from BEVs by 2025.

- When taken in aggregate, cumulative OEM advanced vehicle targets are in line with the IEA 2DS scenario out to 2025. If OEMs achieve their sales targets, the electric car stock could reach over 70 million by 2025[47] (see Figure 41 on page 25).

- Mazda, Subaru and Suzuki are ranked last – all three have upcoming plans to launch BEVs but as yet there are no sales targets associated with these announcements.

47. Includes all company announcements, including Tesla and Chinese OEMs, in addition to sample of 16 companies.

Figure 56: Patents filed for advanced vehicles and batteries

(a)

Company	FCV: Total number of patents / 10,000 automotive employees
Suzuki	100
Hyundai	63
Honda	55
Nissan	53
Toyota	28
Ford	21
Daimler	17
Renault	15
Mazda	15
General Motors	14
Volkswagen	4.3
PSA	1.6
BMW	1.5
Tata Motors	0.9
Subaru	0.7
FCA	0.04

(b)

Company	Electric vehicles: number of world-class patents / 10,000 automotive employees (i)
Toyota	29.1
Nissan	22.5
Honda	17.3
General Motors	14.8
Hyundai	10.9
Subaru	10.4
Ford	8.8
Suzuki	4.5
BMW	4.3
FCA	3.8
Tata Motors	3.2
Renault	2.8
Volkswagen	1.1
Daimler	1.0
Mazda	0.0
PSA	0.0

(c)

Company	Li-ion batteries: number of world-class patents / 10,000 automotive employees
Subaru	6.3
Nissan	3.3
Toyota	2.7
General Motors	1.2
BMW	0.5

Source: Google patents, Bakbasel, company reports

(i) includes hybrids

- Japanese OEMs appear to be leading in terms of innovation. Figures 56 (b) & (c) show that according to the Bakbasel study[48] (which focuses on "world class" patents), Toyota, Nissan and Honda lead on electric vehicle patents and Subaru, Nissan and Toyota lead on Li-ion patents. General Motors picks up fourth place for both technologies. It is a similar story for FCV patents filed (top 5 includes Suzuki, Hyundai, Honda, Nissan and Toyota).[49]

The Tesla test

The presence of Tesla has galvanised the industry. It aims to have fully autonomous vehicles (Level 4) by 2019. By 2020, it's targeting 1 million BEV sales and aiming to reduce battery costs down to US$ 100 / kWh (the magic price at which point many analysts believe BEVs will reach price parity with ICE vehicles.)

Tesla's mission: "to accelerate the advent of sustainable transport" is certainly underway and it intends to offer customers a whole new ecosystem; integrating energy generation, storage and transport.

Despite production bottlenecks affecting Model 3 deliveries (only 1,550 deliveries in Q4 2017), investors remain upbeat. Its new target (to produce 5,000 Model 3s per week by the end of Q2 2018) looks more achievable and in total, Tesla delivered 101,312 Model X and S vehicles in 2017 (a 33% increase from 2016).

One of the most significant innovations of the automotive sector came in 1953 when Toyota introduced its Kanban system (a form of just-in-time manufacturing) minimising work in process inventory and vastly improving manufacturing efficiency. The system transferred more responsibility onto suppliers, significantly changing the OEM-supplier relationship and reducing vertical integration.

However, with the disruptions facing the industry, it remains to be seen if this model is sustainable. Tesla is much more vertically integrated than the incumbent OEMs, producing many of the EV components itself (such as the battery cell and pack). Other carmakers rely on battery suppliers predominantly from Korea or China and with profits expected to shift towards these suppliers over the coming years (see Figure 6 on page 5) this may put them at a disadvantage.

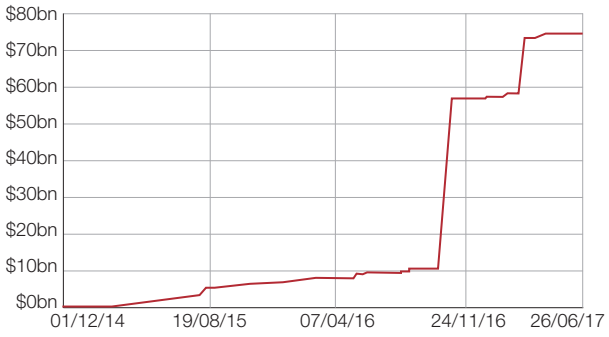
48. The Bakbasel study focuses on patent quality as well as number of patents. It lists the number of "world-class" patents across various technologies.
49. Although outside the scope of this report we note that both Suzuki and Honda also develop and have filed patents relating to fuel-cell motorbikes.

Autonomous driving vehicles (ADVs) and mobility as a service (MaaS)

The total cumulative volume of mainstream transactions in MaaS and ADV related technologies has accelerated rapidly over the last two years, increasing from approximately $6bn in 2015 to over $80bn in 2017 (see Figure 57). This growth is in part driven by growing recognition of the benefits these services and technologies offer, the feasibility of their delivery, as well as a wider acceptance amongst industry experts that both will form an integral part of future transportation systems in the decades to come.

The potential revenues from shared mobility and connectivity services could reach USD$2.2trn by 2030, which is larger than the size of the e-commerce market today.[50] The development and roll-out of ADVs will fundamentally change the form and function of the automotive sector. However, there is a considerable degree of uncertainty about their future take-up, with McKinsey estimating an 8% - 89% range for Level 4 ADV market share by 2040 (see Figure 58).

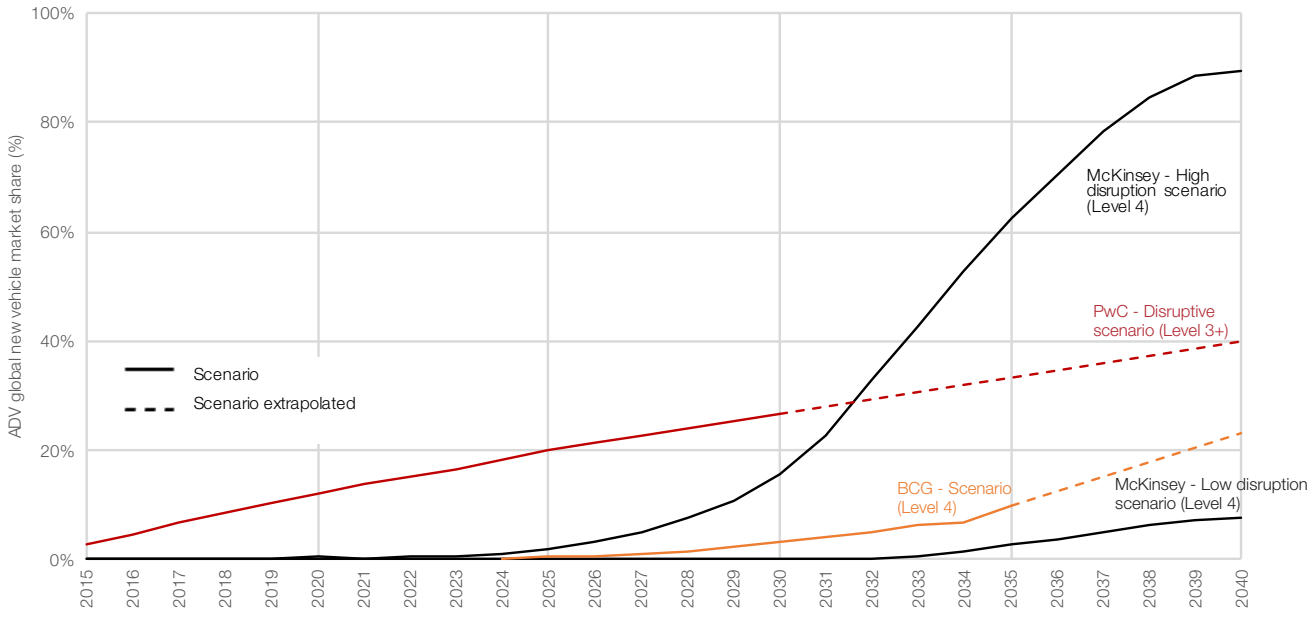
Figure 57: Cumulative investment in ADVs and MaaS



Source: The Brookings Institution

Although the transport industry is driving towards greater automation and an increase in mobility services, the pace of change is uncertain. Nevertheless governments, OEMs, ride-hailing companies and other stakeholders are putting in place the necessary foundations for this future through stakeholder engagement, collaboration and investment. Significant changes are on the horizon and OEMs that are the quickest and most adept in responding to these opportunities will be better placed to capture a share of this new market.

Figure 58: Market share scenarios for autonomous vehicles



Source: BCG, PwC, McKinsey

In this chapter, we assess the extent to which companies are capturing the opportunities available from autonomous vehicles and MaaS using four key metrics:

Metric 1) Investment and acquisitions: We assess each OEMs' total investment expenditure on MaaS and ADV related technologies, normalising total expenditure by revenue over the period.

Metric 2) Partnerships and company services: We assess the total number of partnerships each OEM has with MaaS and ADV related companies whilst also taking account of any relevant internal business divisions / services that have been setup independently.

Metric 3) Autonomous vehicle targets: We look at the aggression of OEMs' automation targets by comparing the target years for specific automation levels (i.e. SAE Levels 1 to 5).[51]

Metric 4) Patents filed and road tests: We account for the total volume of world-class[48] patents that have been filed by each OEM for ADV related technologies, whilst also assessing the performance of ADVs during testing (where performance is based on the number of disengagements per 1,000km driven).

50. The 2017 Strategy& Digital Auto Report, PwC
51. See box on page 37 for further information.

Figure 59: ADVs & MaaS summary

Company	Investment & acquisitions	Partnerships & company services	ADV targets	Patents / road tests	Overall weighted rank	ADVs & MaaS rank
General Motors	3	12	1	1	3.2	1
Ford	4	7	4	2	4.4	2
Volkswagen	6	1	4	3	5.1	3
Nissan	11	7	2	4	5.8	4
Daimler	2	2	8	6	5.9	5
BMW	5	7	4	5	6.0	6
Hyundai	1	5	4	11	6.9	7
Renault	10	10	3	9	7.3	8
Toyota	7	3	12	10	9.1	9
Honda	9	13	10	8	9.5	10
PSA Group	12	3	9	11	10.2	11
Tata Motors	8	11	14	11	11.2	12
FCA	12	5	12	11	11.4	13
Subaru	12	14	15	7	11.9	14
Mazda	12	14	11	11	12.0	15
Suzuki	12	14	15	11	13.3	16
Weighting	**20%**	**15%**	**30%**	**35%**		

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only.

Source: CDP

Highlights

- Since 2015 OEMs, and technology companies have invested more than $80 billion in companies developing MaaS and ADV capabilities whilst also creating numerous strategic partnerships to facilitate their deployment.

- OEMs have taken different strategies in developing MaaS and automation capabilities with some companies like Hyundai focusing on developing inhouse technologies and expertise where others like Ford, Daimler and General Motors have built up their knowledge base through the investment and acquisition of companies who specialise in these fields.

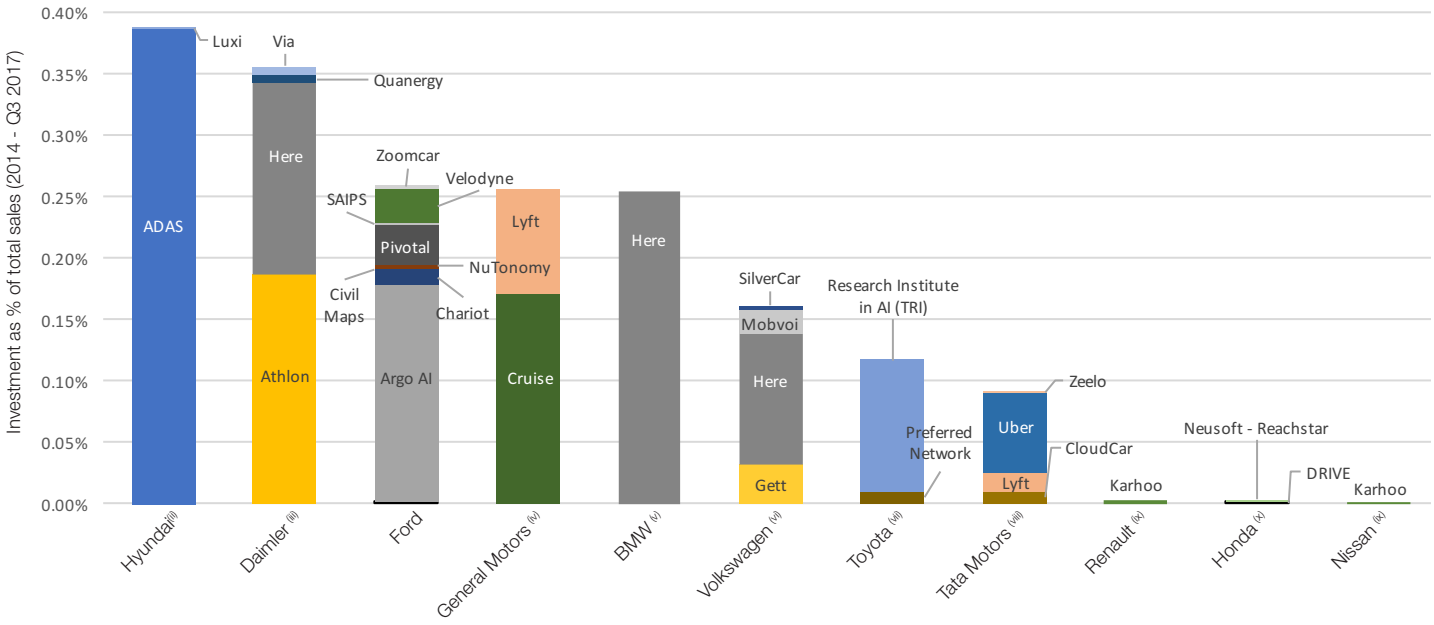
- Of the 16 OEMs included in this analysis more than US$11bn has been invested in developing ADV and MaaS capabilities over the last two years. A closer look at the breakdown of OEM investment expenditure (Figure 60) shows Hyundai rank first on this metric having devoted significant resources towards developing ADAS (an Advanced Driver Assistance System), with a commitment to spending $2bn over a 5-year period. Hyundai have also invested $4.6 million in the ride-sharing service Luxi.

- In second place Daimler's US$1.2bn acquisition of the vehicle leasing service Athlon, and their joint acquisition (with BMW and Volkswagen) of the mapping company HERE, dominate their investment activities. Ford and General Motors follow behind with their most notable activities focusing on autonomous vehicle companies. Ford have invested US$1bn in autonomous vehicle company Argo AI and have made smaller investments in other ADV related companies such as NuTonomy and Velodyne. General Motors' largest outlay went towards the acquisition of the autonomous vehicle company Cruise Automation for around US$1 billion, however General Motors has also invested heavily in the mobility service provider Lyft with a US$500m investment in 2016.

- Of the companies with investment data in the public domain Renault, Honda and Nissan have the lowest investment expenditure relative to their size. In 2017 Renault in partnership with Nissan, acquired the ride-hailing platform Karhoo for $16m. Honda have also invested $9m in a similar Chinese mobility service called Reachstar.

- We note that there have been a significant number of investments with undisclosed amounts – as listed below Figure 60.

Figure 60: Investment and acquisitions [i]



(i) No evidence of investment for FCA, Mazda, PSA, Subaru or Suzuki.
(ii) Hyundai invested an undisclosed amount in Grab and an Intelligent Safety Technology Centre.
(iii) Daimler acquired Hailo and Flinc (undisclosed amounts) and invested in similar mobility services such as Blacklane, Careem and CleverShuttle. It has also invested in Momenta (undisclosed amount) which focuses on developing Deep Learning capabilities for ADVs.
(iv) General Motors acquired Sidecar (ride-sharing) and Strobe (LIDAR tech), also invested in Nauto (AI company) (undisclosed amounts).
(v) BMW have invested in Scoop and Ridecell (ride-sharing) as well as investing in the AI company Nauto (undisclosed amount).
(vi) Volkswagen has invested in Cubic Telecom and TTTech to develop connected and autonomous car capabilities (undisclosed amount).
(vii) Toyota acquired JayBridge Robotics, and invested in Nauto and NVIDIA (ADVs). Have invested in Grab (ride-sharing) (undisclosed amounts).
(viii) Jaguar Land Rover's venture InMotion also invested in Grab, Cove, Go Kid and Sheprd (undisclosed amounts) all of which focus on MaaS.
(ix) Renault-Nissan alliance have acquired mobility services company Sylpheo (undisclosed amount).
(x) Honda has invested in Grab (ride-sharing) and R&D centre X focusing on autonomous driving (undisclosed amounts).

Source: CDP, The Brookings Institution, company reports, press releases

Figure 61: Partnerships and company services

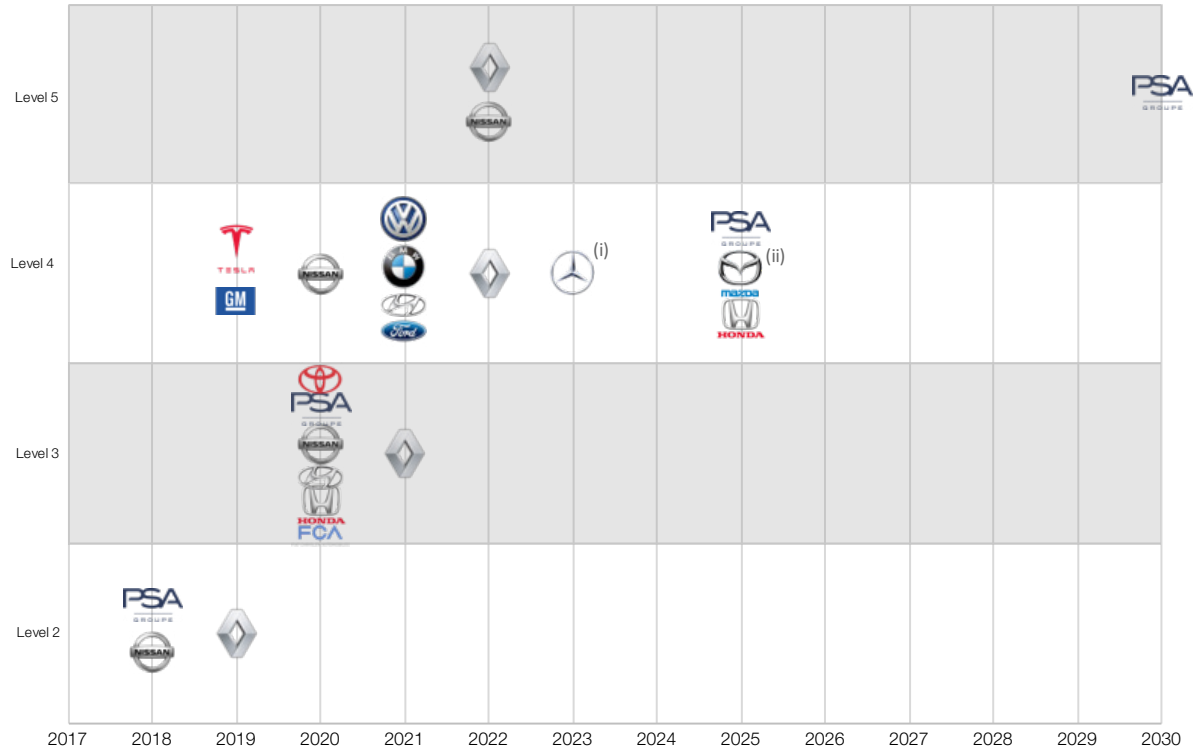
	Partnerships		Company services
Company	ADV	MaaS	MaaS
Volkswagen	Mobileye, NVIDIA, Aurora	Shouqi Group, RideCell, GoFun, Didi	Audi on Demand, Audi Select, Audi shared Fleet, Greenwheels, MOIA, Porsche Pass
Daimler	Bosch, NVIDIA, Uber, Baidu		Car2Go, Car2share Cargo, CharterWay, Croove, Moovel, Mytaxi
PSA Group	VEDECOM, Huawei, NuTonomy	Emov, Koolicar, Bollore	Free2Move
Toyota (i)	KDDI, NTT Group, NVIDIA	Uber, Getaround, Servco	Mobility Services Platform (MSPF)
FCA	Intel & Mobileye, Waymo	Kango, ENI - Enjoy	Fiat Likes U
Hyundai	Cisco, Baidu, Aurora	WaiveCar	DealCar
BMW	Intel & Mobileye	Moovit	ChargeNow, DriveNow, ParkNow, ReachNow
Ford	Lyft, Baidu	Alibaba, Cityhop, Qualcomm	Ford Pass
Nissan	TransDev, DeNA	LeasePlan	e-Share mobi
Renault	TransDev	Carusel	OnePark, Renault Mobility
General Motors		Uber	Maven, BOOK, Express Drive
Tata Motors	Lyft	Ola	
Honda	Waymo, SenseTime		
Subaru		DriveMyCar	
Suzuki		SB Drive	
Mazda (i)			

(i) We also recognise that Toyota and Mazda have formed a partnership which includes collaboration in next-generation areas such as connected and autonomous driving.
Source: CDP, company reports, The Brookings Institution

- As shown in Figure 61, virtually all OEMs operate at least one service or have a partnership with an ADV or MaaS related company. Volkswagen have the highest number of partnerships and company services dedicated to developing these capabilities. These include partnerships with companies Didi, Mobileye and more recently Aurora, as well as the creation of a new mobility service provider MOIA. Daimler and PSA Group follow behind in second and third position with Daimler one of the more active OEMs in developing internal company services.

- Mazda, Subaru and Suzuki are amongst the least active companies in developing strategic partnerships in these areas and rank towards the bottom of the table.

Figure 62: Autonomous vehicle company targets[iii]



(i) Daimler also have plans to develop the Mercedes-Benz Future Truck 2025 that will operate at Level 3.
(ii) Mazda Co-Pilot concept would require technologies equivalent to Level 4, which the company is looking to standardize by 2025.
(iii) We note that Jaguar Land Rover are researching fully autonomous but driveable technology (Level 4) with the FUTURE-TYPE concept, no target dates have been communicated but the company is looking out to 2040.
Source: CDP, company reports

Figure 63: World class ADV patents

Company	Autonomous vehicles: number of world-class patents / 10,000 automotive employees
General Motors	1.16
Ford	0.77
Subaru	0.67
Honda	0.40
Renault	0.33
Toyota	0.32
Volkswagen	0.29
Daimler	0.18
Nissan	0.15

Source: Bakbasel, company reports

Figure 64: ADV road-testing

Company	Number of disengagements / 1,000km driven
Waymo	0.12
BMW	0.99
Ford	3.2
Nissan	4.7
Volkswagen	10.8
GM Cruise	11.5
Delphi	35.8
Tesla	205.6
Mercedes	324.7
Uber	621.4
Bosch	911.4

Source: State of California's Department of Motor Vehicles (DMV)

- 13 out of 16 OEMs have set targets for producing vehicles with autonomous capabilities (Figure 62). General Motors have the most ambitious automation target with plans to deliver an SAE Level 4 vehicle by 2019 and aim to develop a fleet of ADVs to use as part of a driverless taxi service. Nissan and Renault follow in second and third position and are amongst the few OEMs to have set a formal target for delivering Level 5 capabilities; with the alliance aiming to do so by 2022.

- It is unsurprising that General Motors also perform well in the areas of road testing and world class patents for ADVs, as we would expect there to be some correlation between OEMs' performance on this metric and the ambition of an OEMs' automation targets. According to the Bakbasel report, General Motors have the highest number of world class patents per employee relating to ADV technology, followed by Ford and Subaru (Figure 63). Only six OEMs feature in autonomous road-testing data from California's DMV, with BMW, Ford and Nissan amongst the highest performers in terms of number of disengagements per 1,000 km driven. However, OEMs face stiff competition from technology companies – with Waymo (subsidiary of Google) leading on this measure.

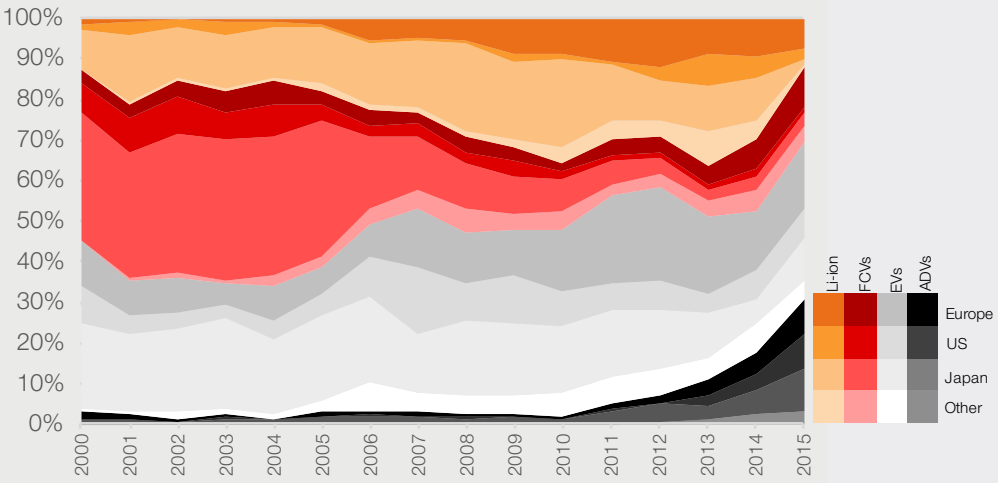
Automation & ride-sharing

Autonomous vehicles and ride-sharing services are set to disrupt the automotive sector by redefining the relationship between the driver, vehicle and environment. The emergence of these technologies and recent developments can be seen as a consequence of the natural innovation process which has led to advances in computational power and Artificial Intelligence (AI). This has allowed companies like Uber and Lyft to utilise smartphones as a platform for delivering new transport services and has made fully autonomous vehicles a viable prospect within the next decade. Together these have the potential to change consumer transport preferences and challenge the traditional business models of OEMs in the years to come.

Figure 65 shows the regional breakdown in the share of patents filed for Electric Vehicles (EVs),[52] Fuel Cell Vehicles (FCVs), Li-ion batteries and Autonomous Driving Vehicle (ADV) related technologies by the OEMs included in this report. A notable feature is the growth experienced in the number of patents relating to ADV technologies which increased from 36 in 2010 to 335 in 2015 (share of total patents across technologies increasing from 2% to 31%). Recent activities within the automotive industry reflect this growing interest, with many OEMs recently communicating targets for the introduction of ADVs.

Another interesting component of Figure 65 is the relative proportion of patents relating to FCV and EV technologies. In the year 2000 there was relative parity in the proportion of patents; both 42% of total patents. By 2015 FCVs accounted for only 18% of patents filed compared to 39% for EVs. Although patent data is not a direct indicator of innovative output, the reduction in the patent count for FCVs does suggest a shift in focus toward electric and hybrid combinations. This is also reflected in the shift in business strategy of the OEMs traditionally seen as the drivers of FCV technology within the industry. Honda, Hyundai and Toyota have all now shifted some focus towards EVs whilst Daimler have indicated that FCVs no longer form a major part of their plans.

Figure 65: Technology share of patents by region (filed by 16 OEMs)



Source: Google patents

Figure 66: SAE levels of automation

Source: Marketwatch, SAE International

Figure 66 illustrates the SAE International standards for different automation levels, with Level 1 providing a limited form of driver assistance, up to Level 5 where no human monitoring is required. The economic and social benefits of highly automated vehicles are significant with reduced damages from road accidents[53] and improved productivity as commuting time is recovered.[54] However, at present there exist a number of regulatory obstacles that need to be addressed as well as wider legal ambiguities relating to personal liability that have to be clarified. But there are signs governments are beginning to engage with these issues, with some having already provided clarity for OEMs, insurers and other stakeholders (such as the Vehicle Technology and Aviation Bill recently passed in the UK).

By 2035 the global market for ADVs is estimated to value $1.2tn and by 2050 they will form part of a wider 'passenger economy' worth $7tn, where driverless vehicle services form an integral part of the transport system.[55] We are already beginning to witness the realisation of this future with OEMs like General Motors, Nissan and Daimler working in partnership with ride-hailing companies to develop driverless taxi services; with the earliest service expected in 2019. The availability of these services has created a generational shift in attitude towards car ownership with millennials displaying greater willingness to ride-share as an alternative.[56]

The combination of MaaS services and an appetite for alternatives to car-ownership amongst younger prospective car owners presents a challenge for the automotive industry. Saudi Aramco view these forces and their potential impact on vehicle sales as a more immediate disruptive force to transport and energy use than the rise of EVs.[57] However, McKinsey show how increased urbanisation and economic growth will continue to drive increases in vehicle sales in the near term but that the net effect of shared mobility services will act as a dampener on growth.[58] The development of ADVs and the role they can play in supporting MaaS capabilities can only be expected to exacerbate these risks longer term. However, OEMs need not view this as an existential threat but should recognise the integral role they play in driving these changes and shaping the future trajectory of the market.

52. EVs include battery electric vehicles and hybrids.
53. The WHO estimate that 1.3 million people are killed per year by road accidents (2.2% of global deaths) equating to a cost of US$2-3 trillion per year (around 3% of global GDP).
54. Accelerating the Future: The Economic Impact of the Emerging Passenger Economy, Lanctot, R., Strategy Analytics & Intel.
55. Market Forecast: For Connected and Autonomous Vehicles, Catapult.
56. Cars-2025, Goldman Sachs
57. Saudi Aramco executives see ride-sharing as threat to oil demand, Financial Times, 2017
58. How shared mobility will change the automotive industry, McKinsey

- The automotive sector scores well on innovation with high R&D expenditure as a proportion of sales compared to other industry groups (average for 16 companies is 4.6%).[59] Volkswagen and Tata Motors take the lead with Hyundai and FCA spending much less as a proportion of sales (Figure 67). However, this is only part of the story and when you compare these numbers against the companies leading in "world class" patents as was shown in Figures 56 & 63, it suggests that companies such as Toyota have better R&D efficiency. Indeed, going forward where companies choose to focus their R&D efforts will be crucial, with perhaps a greater need to allocate more spending to disruptive technologies and areas such as machine learning.

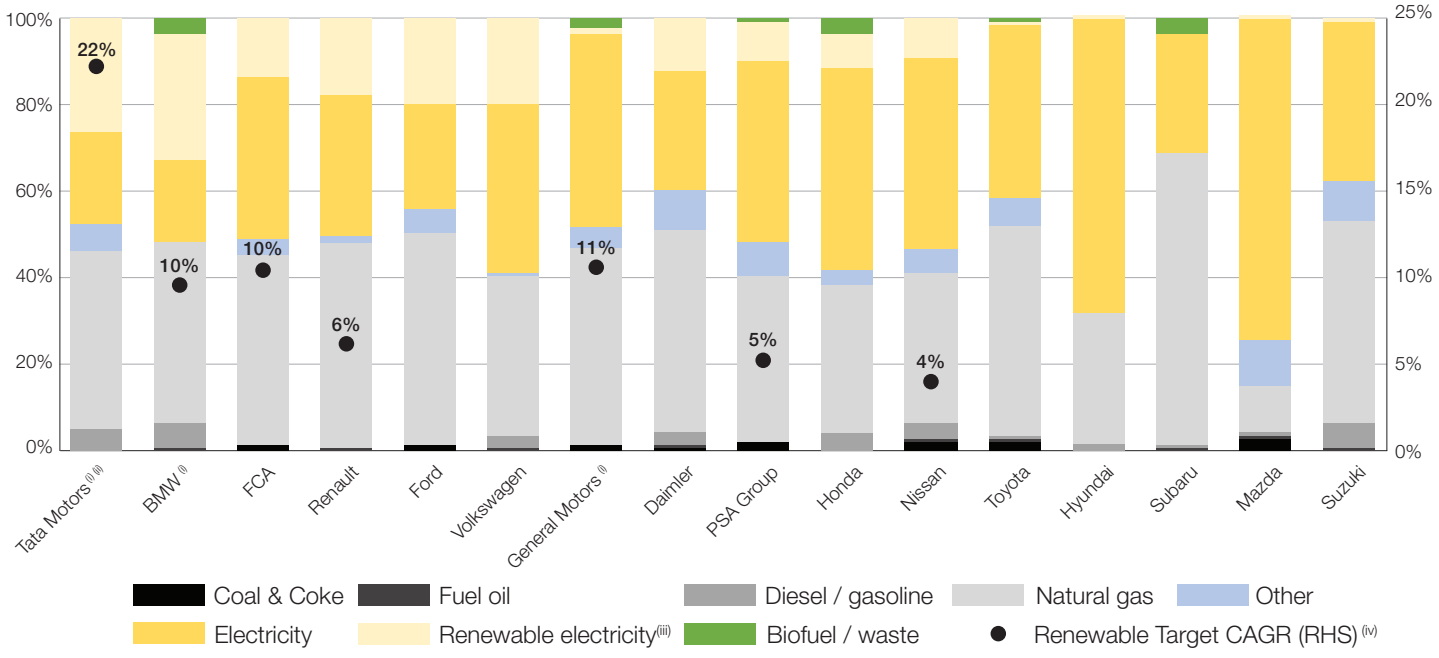
- Figure 68 shows the different sources of energy used by companies in their operations. Tata Motors comes out on top with a commitment to the RE100 initiative, an aggressive renewable energy target and a significant proportion of energy consumption sourced from renewables (Jaguar Land Rover currently sources over 90% of its electricity from renewables). With energy accounting for up to 10% of operational costs, smart energy solutions offer an opportunity to optimize costs and manufacturing emissions intensity concerns.

Figure 67: Research and development (R&D)

Company	R&D / Net sales 2014-2016
Volkswagen	6.4%
Tata Motors	6.3%
BMW	5.6%
Honda	4.9%
General Motors	4.8%
Ford	4.6%
Daimler	4.6%
Renault	4.5%
Nissan	4.3%
PSA Group	4.3%
Suzuki	4.1%
Toyota	3.7%
Mazda	3.6%
Subaru	3.2%
FCA	2.7%
Hyundai	2.4%

Source: CDP, company reports

Figure 68: Energy consumption split by resource type (2016)



(i) BMW, General Motors & Tata Motors are members of the RE100 initiative.
(ii) Combined Energy mix for Tata and Jaguar Land Rover. RE 100 and renewable energy target refers to Tata operations only.
(iii) Where data is available and / or reported in CC11.4 of CDP questionnaire.
(iv) Where renewable energy target is available.
Source: CDP, company reports

59. Though it should be noted that technology companies often have R&D to sales ratios of between 10 – 15%. See Figure 7 on page 5 for further discussion.

Climate governance & strategy

- The use of Life-Cycle Analysis to assess emissions from 'well to wheel' is well-established within the industry, with all companies conducting some form of the analysis.
- Seven companies have committed to or support long term Science Based Targets; however, three auto manufacturers have yet to set Scope 3 emissions reduction targets.
- European companies lead on governance with a greater focus on climate linked remuneration and climate expertise at board level.
- Renault, BMW and Toyota rank highest. Suzuki, Hyundai and Subaru rank lowest.

Overview

Comprehensive long-term business strategies and governance measures aligned with a low-carbon future can ensure that companies are well placed to survive and capture the opportunities presented by this rapidly changing sector.

With the recommendations made by the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD), the mandated disclosure on climate risk and opportunities is likely to become the business norm, while there is a growing awareness of the need for all sectors to put in place climate risk management strategies and enhanced disclosure for the benefit of investors and stakeholders.[60]

The incorporation of climate-related factors into decision-making provides an insight into how successful companies will be in adhering to increasingly stringent regulations and transitioning away from incumbent business models based around the internal combustion engine (ICE).

The setting of long term emissions reduction targets aligned with the Science-based Targets Initiative (SBTi) give an indication of the levels of ambition companies have in reducing emissions across their entire business operations. The incorporation of climate-remuneration practices also allows investors to ascertain the level in which climate related issues have been incorporated at a senior executive and board level.

With most OEM's sourcing an extensive list of materials through suppliers, it is also important for companies to manage emissions throughout the value chain through supplier engagement and life-cycle analysis (see box on page 12).

Figure 69: Climate governance and strategy summary

Company	Supplier engagement & life-cycle analysis	Emissions targets	Data assurance	Use of internal carbon price	Remuneration	Board level expertise	Water	CDP Score	Overall weighted rank	Climate governance & strategy rank
Renault	3	6	1	4	2	6	16	A-	4.6	1
BMW	8	5	2	3	3	3	11	A	4.6	2
Toyota	2	1	11	10	12	9	4	A	5.7	3
FCA	1	15	3	4	5	1	1	A-	6.1	4
Nissan	7	2	9	4	10	13	6	A-	6.7	5
Daimler	6	8	8	4	4	10	13	A-	6.7	6
PSA Group	13	9	7	10	1	5	14	A-	7.0	7
Volkswagen	5	7	4	4	9	8	5	A-	7.0	8
Tata Motors (i)	10	10	12	2	8	2	9	B	7.1	9
Mazda	4	3	14	4	14	11	3	A-	7.2	10
Ford	12	11	10	13	5	4	2	A-	7.5	11
General Motors	11	13	5	1	7	7	8	A-	8.0	12
Honda	9	4	6	10	10	16	7	A-	8.1	13
Suzuki	14	12	16	13	15	12	10	B	11.6	14
Hyundai	15	14	13	13	12	13	15	A-	14.1	15
Subaru	16	16	15	13	15	15	12	B	15.2	16
Weighting	**25%**	**25%**	**5%**	**5%**	**15%**	**10%**	**10%**	**5%**		

(i) Analysis for Tata Motors includes fully owned subsidiary Jaguar Land Rover.
Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only.
Source: CDP

60. We note that within this sample, Daimler are the only official supporter of the TCFD as of the One Planet Summit in December 2017.

In this section, we assess how companies are planning for a low-carbon future through aligning their governance structure with the associated risks and opportunities presented by the transition. We rank companies on their climate governance and strategy using the following key metrics:

Metric 1) Supplier engagement and life-cycle analysis: We assess supplier engagement practices across a number of climate related factors. Companies are scored based on the percentage of suppliers engaged with as a percentage of total spend, whether staff are incentivised to engage with their suppliers, the reporting of upstream Scope 3 emissions and the extent to which companies are using life-cycle analysis (LCA) to determine emissions over the life cycle of their fleet.

Metric 2) Emissions reduction targets: We assess the coverage and strength of companies' emissions reduction targets and levels of commitment to the SBTi.

Metric 3) Emissions data verification: We form a scorecard approach that assess companies' emissions accounting procedures. This includes: level of third party verification and assurance, scope of verification and levels of uncertainty.

Metric 4) Use of internal carbon price: This metric is used to identify the extent to which internal carbon prices, are incorporated into future capital expenditure plans and other key business decisions.

Metric 5) Climate-related remuneration: We assess alignment between climate-risk strategy performance and remuneration across long-term incentives and short-term annual bonus programs at the senior executive and board level as well as other climate-risk remuneration practices at broader corporate levels.

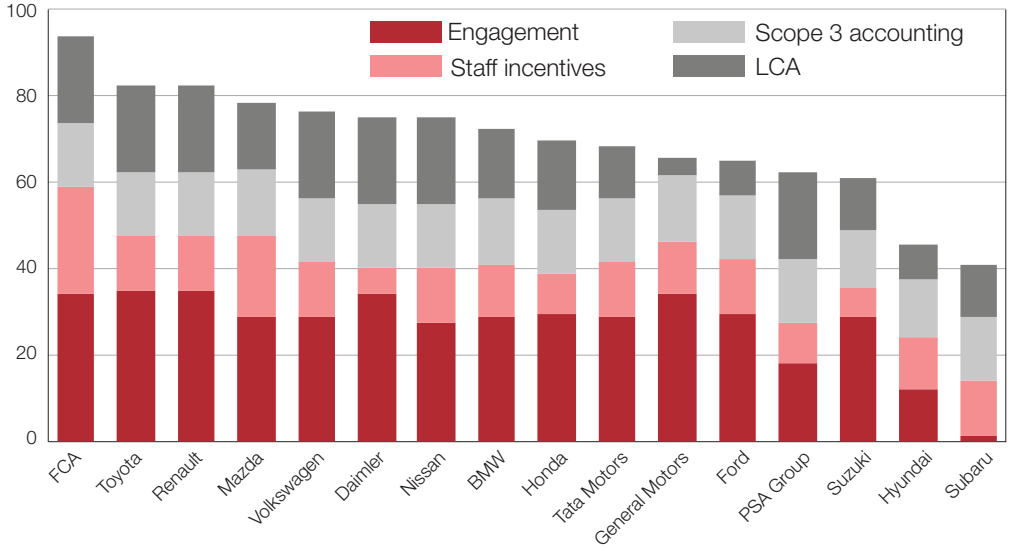
Metric 6) Board level climate responsibility and expertise: Companies are assessed on a number of factors relating to board and executive climate responsibility performance including the level of directors on the board with climate related experience, the presence of climate-related committees (at board and/or executive levels) and the overall quality of climate-risk management systems.

Metric 7) Water withdrawal intensity and management: Water withdrawal intensity is used to evaluate companies' dependency on water supply. We assess current water withdrawal intensity levels and the extent to which companies have reduced withdrawals from 2010-2016. We also incorporate the 2017 CDP water score to ascertain levels of management and disclosure of water-related issues.

Metric 8) CDP Score: The 2017 CDP Score provides an aggregate measure of the quality of climate-related disclosure and management systems addressing climate risks.[61]

Figure 70: Supplier engagement

Company	Suppliers engaged as % of total spend
FCA	100%
Toyota	100%
Mazda	100%
Daimler	100%
Suzuki	100%
Renault	82%
BMW	81%
Honda	80%
Tata Motors	68%
Ford	65%
General Motors	60%
Nissan	51%
Volkswagen	43%
PSA Group	22%
Hyundai	1%
Subaru	0%



Source: CDP, company reports

61. In the next CDP reporting cycle (2018) CDP is moving to sector specific questionnaires which will align with the TCFD recommendations.

Highlights

- Renault ranks first overall in climate governance & strategy. The company performs consistently well across most metrics, with comprehensive emissions reduction targets, high-levels of data assurance and supplier engagement and a holistic life-cycle analysis (LCA) procedure.
- BMW, Toyota and FCA perform strongly overall. Toyota score among the top two for both supplier engagement and emissions reduction targets. FCA perform consistently well across most metrics but its emissions reduction targets are at odds with its wider climate governance practices.
- The bottom three companies Suzuki, Hyundai and Subaru perform poorly across all metrics with basic levels of governance and awareness of climate-related issues, in stark contrast to the majority of their competitors.

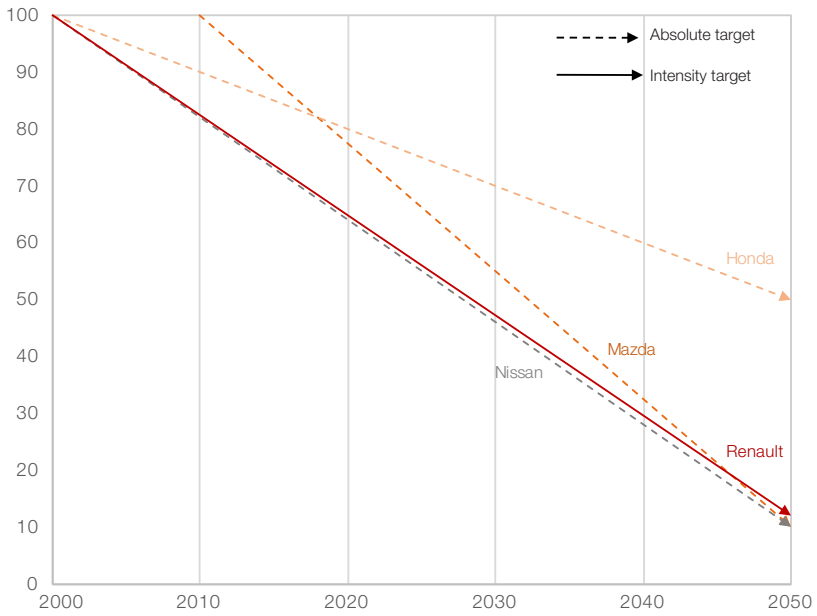
Supplier engagement and life-cycle analysis

- OEMs are dependent on their supply chains for the continuity of business operations. With supplier emissions (upstream purchased goods and services) accounting for 18% of total emissions,[62] engagement throughout the value chain is an essential governance practice for reducing emissions. Using the percentage of total spend as an indicator of engagement, Figure 70 shows that the majority of companies within the sample engage with their suppliers on GHG emissions and climate change strategies, with five of the 16 companies demonstrating 100% engagement with suppliers within the value chain.
- Figure 70 indicates all companies show some degree of Upstream Scope 3 emissions accounting and incentivize staff in regard to incorporating environmental criteria in purchases and supplier engagement.
- Most companies demonstrate some use of life-cycle analysis (LCA) to track the environmental impact of vehicle production, use and disposal from 'well to wheel'. FCA, Renault and PSA Group all incorporate "circular economy" principles (where resources are recycled and reused for as long as possible within the value chain) into their business approach and complete LCA on most or all of their existing and new models. General Motors are the only company to show little evidence of conducting in-depth LCA.
- Renault take a holistic and comprehensive approach to LCA, applying a methodology that considers not only CO_2 emissions but also the depletion of natural resources; low-level ozone; the acidification of lakes, soil and forests; and eutrophication. Daimler and Volkswagen also consider Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOC) emissions in their analysis.

Emissions reduction targets

- The standard of emissions reduction targets is relatively strong within the cross-section of companies, with all but 3 setting a combination of targets covering scopes 1,2+3. 50% have set absolute scope 1+2 targets and 30% have set absolute scope 3 emissions targets as opposed to intensity targets. Seven companies have also committed to or support the SBTi and are awaiting the decarbonization pathway sector guidance to formalize their targets.[63]
- The top four companies are from Japan. All four have absolute emissions targets covering Scope 1,2+3 emissions. Toyota tops the rankings with comprehensive targets within its "Environmental Challenge 2050", looking to reduce vehicle CO_2 emissions by 90% by 2050 and to work towards reaching zero CO_2 emissions in the entire vehicle life cycle. Nissan, Mazda and Honda rank 2nd, 3rd and 4th respectively, with Nissan and Mazda aiming for a 90% reduction and Honda a 50% reduction by 2050 (see Figure 71).
- Hyundai, Subaru and FCA rank in the bottom three with FCA ranking last. These companies have not set a Scope 3 emissions reduction target and have among the weakest scope 1+2 emissions targets. As shown in Figure 73, Hyundai and Subaru have weak reduction rates at 1% p.a. FCA's target only covers 56% of total scope 1+2 emissions, the lowest of all companies.

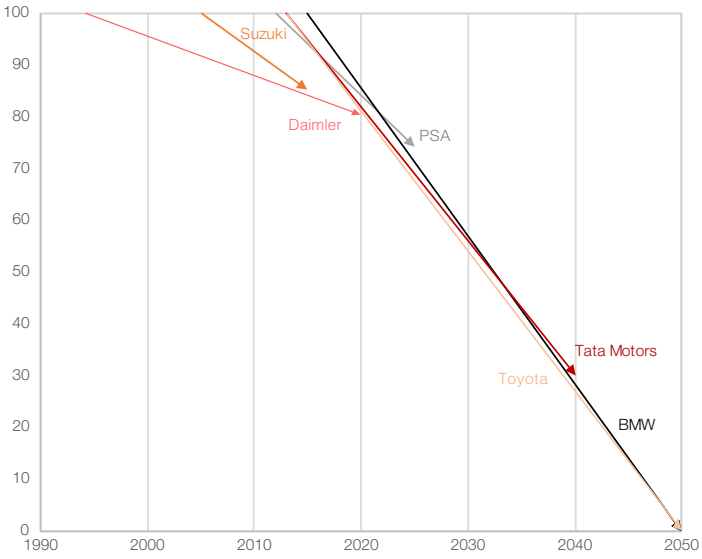
Figure 71: Scope 1,2+3 combined emissions reduction targets (base year indexed to 100)



Source: CDP, company reports

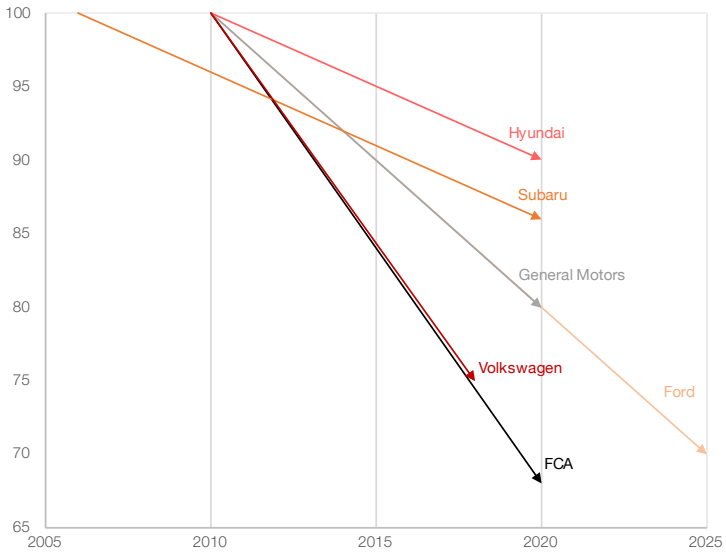
62. See Figure 9 on page 9 for detailed breakdown.
63. The SBTi decarbonization pathway and tool guidance for the autos sectors are in development and are expected to be available in Q1 2018.

Figure 72: Scope 1+2 Absolute emissions reduction targets (base year indexed to 100)



Source: CDP, company reports

Figure 73: Scope 1+2 Intensity emissions reduction targets (base year indexed to 100)



Source: CDP, company reports

- With total Scope 3 emissions accounting for 97% of emissions, Scope 3 emissions reduction targets are significantly more important than scope 1+2 targets. Figure 74 shows that Toyota, Mazda, General Motors, Nissan, Volkswagen, Jaguar Land Rover (Tata Motors) and Daimler have set relatively aggressive Scope 3 targets with reduction rates of over 4% p.a.

- We consider absolute targets to be a more ambitious than intensity targets (the SBTi states that intensity targets are only eligible when they lead to absolute emissions reductions). The SBTi also recommends choosing the most recent year for which data is available and so a number of companies including Daimler, Honda, Nissan, Subaru and Suzuki should look to update their base years for certain targets.

Figure 74: Scope 3 emissions reduction targets and participation in the Science-Based Targets Initiative

Company	Science Based target support / commitment	Absolute / intensity target	Base year	Target year	% reduction from base year	Target CAGR
Toyota(i)	✓	Absolute	2010	2050	90%	-5.6%
Mazda	✗	Absolute	2010	2050	90%	-5.6%
Nissan	✓	Absolute	2000	2050	70%	-4.5%
Honda	✓	Absolute	2000	2050	50%	-1.4%
Volkswagen	✗	Absolute	2006	2020	45%	-4.2%
Renault	✓	Intensity	2000	2050	88%	-4.2%
Daimler	✓	Intensity	2010	2021	37%	-4.1%
Suzuki	✗	Intensity	2006	2015	25%	-3.1%
BMW	✓	Intensity	2008	2020	25%	-2.4%
Jaguar Land Rover	✗	Intensity	2007	2021	45%	-4.2%
Ford	✗	Intensity	2010	2030	48%	-3.2%
PSA Group	✓	Intensity	2012	2025	30%	-2.7%
General Motors	✗	Intensity	2013	2020	28%	-4.5%
FCA	✗	No target				
Hyundai	✗	No target				
Subaru	✗	No target				

(i) With its "Environmental Challenge 2050" Toyota is also working towards reaching zero CO_2 emissions in the entire vehicle life cycle.
Source: CDP, company reports, SBTi

Emissions data verification and internal carbon pricing

- Renault ranks first for emissions data verification achieving reasonable assurance for 100% of its scope 1+2 emissions and limited data assurance for its scope 3 emissions. The company provides scope 1+2 emissions data within its accounting methodology with an uncertainty of less than 2%.

- Suzuki rank last in this metric with no data verification across the three Scopes and the highest levels of uncertainty in its emissions accounting. Subaru rank second from last with only 2% of its Scope 1+2 emissions verified and no Scope 3 verification. Ford, Hyundai and Mazda are let down by little or no Scope 3 emissions verification.

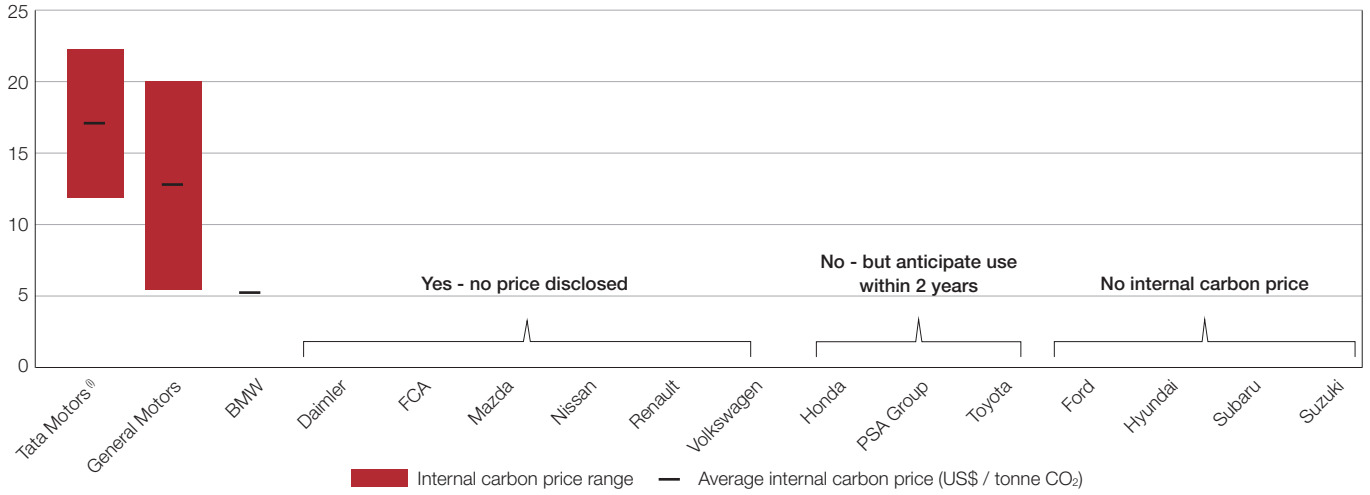
- Only three companies, disclose a carbon price. Tata Motors set the most aggressive average price of $17/tonne CO_2, while General Motors and BMW set an average price of over $12/tonne CO_2 and $5/tonne CO_2 respectively. Though six companies claim to use a carbon price internally they do not disclose the figure to CDP. With increasing pressure to ramp up future carbon pricing legislation to align with a below 2-degree future, companies already considering the impacts of carbon pricing are likely to be better positioned to deal with regulatory changes.

Figure 75: Emissions data verification

Company	Scope 1 assurance type	Proportion of scope 1 verified	Uncertainty scope 1 verified	Scope 2 assurance type	Proportion of scope 2 verified	Uncertainty scope 2 verified	Scope 3 assurance type	Proportion of scope 3 verified	Total score	Rank
Renault	Reasonable	100%	≤ 2%	Reasonable	100%	≤ 2%	Limited	96%	24.4	1
BMW	Limited	100%	≤ 2%	Limited	100%	≤ 2%	Limited	99%	20.7	2
FCA	Limited	100%	≤ 2%	Limited	100%	2 - 5%	Limited	99%	20.4	3
Volkswagen	Limited	98%	≤ 2%	Limited	100%	≤ 2%	Limited	92%	20.0	4
General Motors	Limited	94%	≤ 2%	Limited	100%	2 - 5%	Limited	97%	19.9	5
Honda	Limited	100%	≤ 2%	Limited	100%	≤ 2%	Limited	84%	19.6	6
PSA Group	Reasonable	100%	≤ 2%	Reasonable	100%	≤ 2%	Limited	26%	19.5	7
Daimler	Limited	100%	≤ 2%	Limited	100%	2 - 5%	Limited	70%	18.4	8
Nissan	Limited	87%	2 - 5%	Limited	88%	2 - 5%	Limited	88%	17.8	9
Ford	Reasonable	100%	≤ 2%	Reasonable	100%	≤ 2%	None		17.6	10
Toyota	Limited	100%	≤ 2%	Limited	100%	≤ 2%	Limited	51%	17.3	11
Tata Motors (i)	Moderate	100%	5 - 10%	Moderate	100%	5 - 10%	Moderate	100%	15.6	12
Hyundai	Reasonable	80%	≤ 2%	Reasonable	75%	≤ 2%	None		13.7	13
Mazda	Limited	81%	2 - 5%	Limited	86%	2 - 5%	Limited	1%	11.2	14
Subaru	Reasonable	2%	2 - 5%	Reasonable	2%	2 - 5%	None		0.3	15
Suzuki	None		5 - 10%	None		5 - 10%	None		0.0	16

(i) Average score for Tata Motors and Jaguar Land Rover CDP response. Jaguar Land Rover had no third party verfication for Scope 2 or 3 emissions.
Source: CDP

Figure 76: Use of an internal carbon price



(i) Jaguar Land Rover subsidiary only.
Source: CDP, company reports

Physical risks – Air pollution and the death of diesel

Ambient air pollution kills around 3 million people annually and ranks as the fourth-largest overall risk factor for human health worldwide (WHO).[64] In recent years, with the rapid uptake of vehicles across the globe, issues of air pollution from toxic particulates has become a pressing issue for governments and cities, and called into question the viability of diesel engines.

Petrol vs. diesel

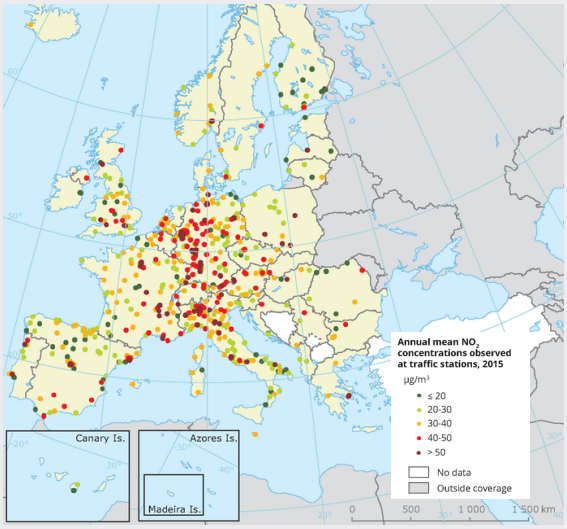
In response to concerns over the automotive industry's contribution to climate change, diesel engines were once promoted throughout Europe as a cleaner alternative to petrol cars, due to their greater fuel economy. Despite diesel containing slightly more carbon than petrol (2.68kg CO_2/litre to 2.31kg CO_2/litre), due to the greater fuel efficiency of diesel engines, diesel cars emits less CO_2 per km than petrol cars.

However, under the Euro 6 EU standards, new petrol and diesel models have been shown to produce almost identical levels of CO_2, yet diesel vehicles produce higher levels of pollutants such as nitrogen oxides (NO_x), linked to poor air quality and health problems. In contrast, the fitting of catalytic converters to petrol vehicles enables the conversion of harmful pollutants into more benign gases resulting in around 30% less NO_x emissions than diesel vehicles.[65] The EU-wide plan to encourage the buying of diesel vehicles therefore has led to an inherent conflict between air pollution policy and climate change policy.

Nitrogen Oxides and $PM_{2.5}$

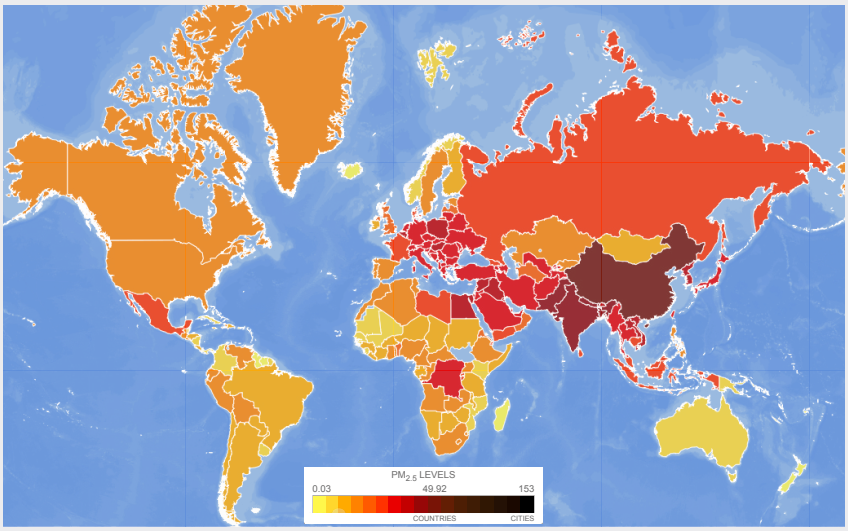
At the root of the problem are two toxic substances, NO_x and particulate matter ($PM_{2.5}$) both of which are emitted by diesel engines. Diesel engines produce nitrogen dioxide (NO_2) – shown to be the cause of a number of respiratory problems that can lead to premature death and the greenhouse gas nitrous oxide (N_2O). The annual EU limit value for NO_2, was widely exceeded across Europe in 2015, with 89% of incidents occurring at roadside monitoring locations (see Figure 77).[66] In European cities such as London, Paris and Munich where diesel vehicles are commonplace, NO_2 levels are often twice the EU legal limit.

Figure 77: Annual mean NO_2 concentrations observed at traffic stations (2015)



Source: European Energy Agency

Figure 78: $PM_{2.5}$ levels across the globe



Source: VFA solutions

Particulate matter ($PM_{2.5}$), also known as black carbon, refers to very fine soot particles associated with a number of adverse health conditions. Figure 78 represents the $PM_{2.5}$ particulate matter concentration across the globe.[67] According to the WHO it is estimated that around 85% of people in urban areas are exposed to harmful levels of $PM_{2.5}$.[68]

Diesel-gate scandal

In September 2015, the EPA discovered that Volkswagen had fitted illegal "defeat devices"[69] to around 590,000 vehicles in the US, with an estimated total of 11 million vehicles worldwide found to have cheated pollution checks as a result of the device. A subsequent study by the International Council on Clean Transportation (ICCT) into vehicles under the Euro 6 standards has exposed widespread inadequacies of the industry addressing the levels of NO_x emitted by new diesel vehicles.

The study, conducted under the real-driving emissions test procedure (RDE)[70] shows that 90% of vehicles exceed acceptable NO_x levels[71] (Figure 79). The extent to which many carmakers had exceeded the limits, despite the viability of producing "clean" diesel engines, has had wide-spread regulatory, and reputational repercussions that could spell the end for diesel.

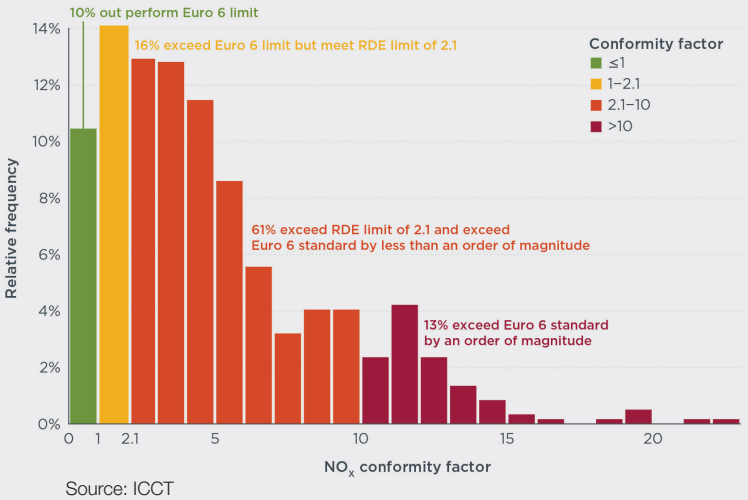
64. World Health Organization, 2016, Ambient air pollution: A global assessment of exposure and burden of disease
65. Khan S. 2017, Fact Check: are diesel cars really more polluting than petrol cars? https://theconversation.com
66. European Environment Agency, 2017, Annual mean NO_2 concentrations observed at traffic stations – 2015
67. $PM_{2.5}$ is measured in µg/m³ (http://visuals.datadriven.yale.edu/airmap/)
68. BBC (2016) Air pollution 'causes 467,000 premature deaths a year in Europe'
69. Software that can perceive when the vehicle is under test conditions and adjusts the engine accordingly to ensure nitrogen oxide pollutants stay below test limits.
70. The RDE procedure is a new on-road emissions test that was recently introduced by the European Union (EU) as an amendment to the Euro 6 standard. RDE testing will come into force for new EU emissions type approvals beginning in September 2017.
71. Baldino C. et al. 2017, Road Tested: Comparative overview of real-world versus type-approval NO_x and CO_2 emissions from diesel cars in Europe, White paper, ICCT

Impact of the scandal

Total costs for Volkswagen as a result of the scandal have reached an estimated $30bn; owing to legal fines, the repurchasing of faulty vehicles and modifications of affected cars.

The Mayors of Paris, Mexico City, Madrid and Athens have proposed to ban diesel vehicles by 2025, while London has imposed a so-called "toxin tax", where drivers of older diesels will be charged up to £20 per day to drive into central London. France and the UK are also proposing to end sales of diesel and petrol vehicles by 2040, India aims for full electrification of vehicle sales by 2030, while China has suggested that it may consider banning the production and sale of fossil fuel cars in the near future to enhance efforts to ease pollution and increase the uptake of electric vehicles.[72]

Figure 79: NO_x measurements of Euro 6 diesel passenger cars



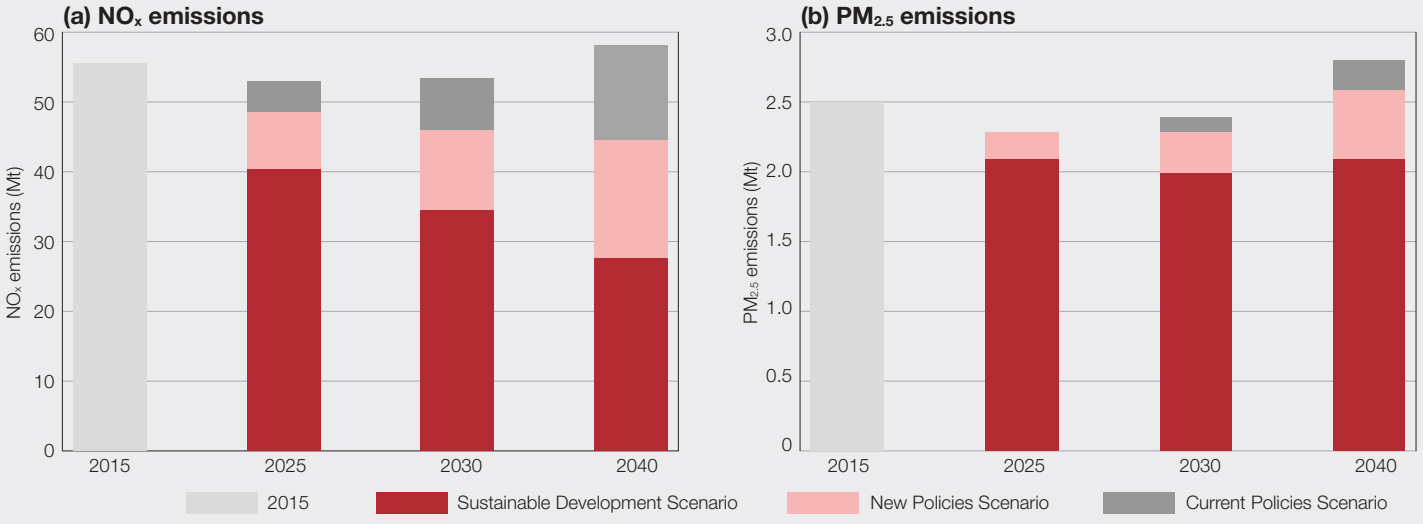
Source: ICCT

The end of diesel?

With a lack of commercially viable alternatives, heavy goods vehicles relying on diesel are likely to play a part in many commercial vehicle fleets for the foreseeable future and have by and large, been left out of many regulatory reforms, (See box "Electrons for 18 wheels" on page 22) yet the future of diesel passenger cars is more uncertain.

The crux of the situation is that manufacturers had the solutions for reducing pollutant levels well before the revelations of diesel-gate came to public attention. The most commonplace answer for reducing emissions is to use Selective Catalytic Reduction (SCR) systems, a technology that uses urea based additive known as "AdBlue" and a catalytic converter that converts NO_2 into water vapour atmospheric nitrogen.[73] Though the use of AdBlue has been used in buses and HGVs for several years, most new cars and light commercial vehicles sold in the EU will require AdBlue to comply with EU6 standards for exhaust emissions. However, it requires the driver to regularly add the substance to the engine and the misuse or failure to top up can damage the vehicle.

Figure 80: Scenarios for NO_x and $PM_{2.5}$ emissions from the transport sector



Source: CDP, IEA WEO 2017

Figure 80 (a) & (b) are taken from the IEA's 2017 World Energy Outlook scenario analysis. In the New Policies Scenario, NO_x emissions – predominately from road vehicles – fall by nearly 20% by 2040, despite a doubling of the vehicle fleet. The reduction is mainly due to an increase in uptake of EVs and stringent regulations on cars and trucks. $PM_{2.5}$ emissions remain flat as improvements in emissions standards for trucks are offset by the overall increase in the global car and truck fleet (Figure 80 (b)). In the Sustainable Development Scenario, by 2040, NO_x levels are reduced by 35% and $PM_{2.5}$ levels by 25% below the level of the New Policies Scenario with the decline in $PM_{2.5}$ emissions reduced by the continued increase in the distance driven by cars and trucks.[74]

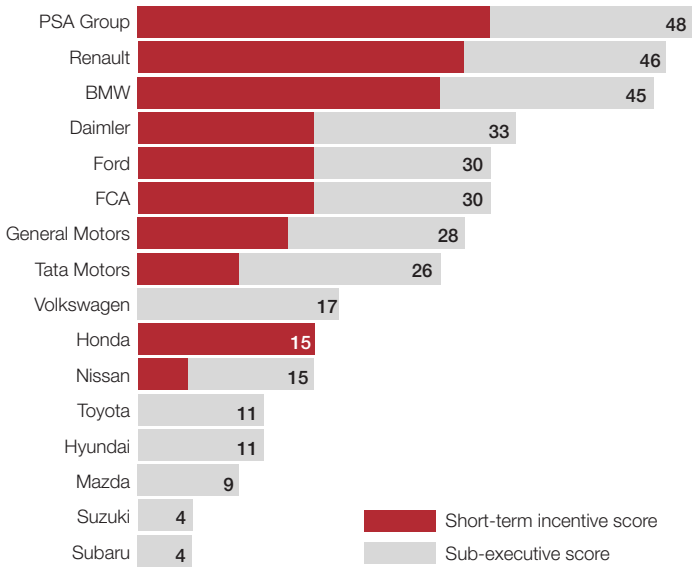
In the wake of the diesel scandal and widespread failure of OEMs to adhere to diesel standards coupled with the health implications of the pollutants emitted by diesel engines, there has been a marked decrease in diesel car sales. Equally, vehicle manufacturers are likely to shift away from diesel technology in response to tighter NO_x emission standards and government programs to discourage diesel vehicle use. While the availability of cheaper and more environmentally friendly alternatives is set to increase, market trends point to a continuing slide in diesel sales.

72. See Figure 87 on page 48 for further detail of specific country targets.
73. VDA, 2016, AdBlue, https://www.vda.de/en/topics/innovation-and-technology/ad-blue/AdBlue-brand-list-and-licensees-list.html
74. World Energy Outlook, 2017, International Energy Agency

Climate-related remuneration

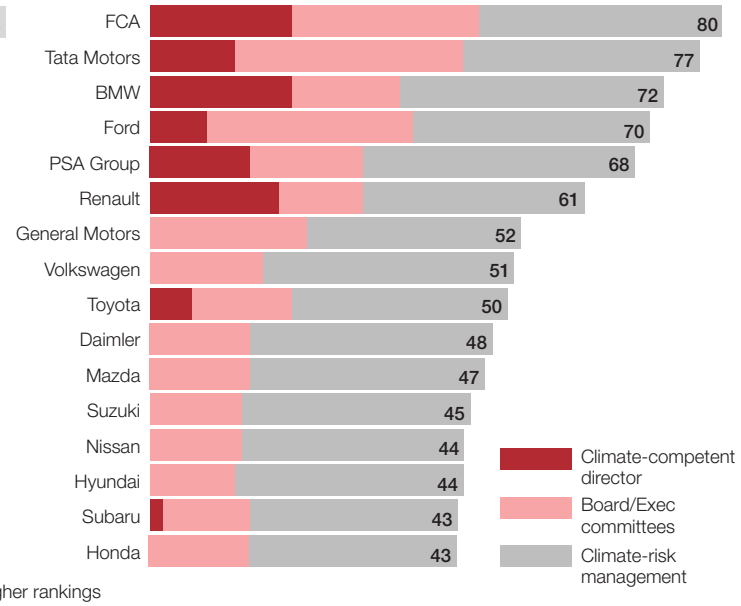
- Overall, the companies within the sample were found to exhibit weak to average performance on climate-related remuneration, largely in part to the absence of climate-related long-term incentive programs (see Figure 81).
- PSA Group ranks first in climate related remuneration. In 2016, the executive chair's annual bonus program links 5% of the bonus to performance tested against a CO_2 emissions reduction KPI, of which 75% is reported to have been achieved for the 2016 financial year. In 2017, the emissions target was also enhanced. The company's managing board and executive committee have their annual bonuses linked to vehicle efficiency targets (including reducing weight, energy consumption and CO_2 emissions reduction targets).
- Renault links up to 4.4% of its Chair and CEO's short-term incentive bonus with the 'quality of CSR and environmental commitments' KPI, which includes the positioning in Europe in electric vehicles. BMW operates a single variable incentive program whereby elements of both short-term and mid-term incentive programs are combined. However, the cash incentive directly related to the carbon emissions KPI has not been disclosed.
- Ten out of the 16 companies include some form of short term climate-risk assessment in determining annual bonus outcomes at the senior executive and board level (see Figure 81). 15 of the 16 companies incorporate some form of climate-relevant performance requirements into their remuneration structures applicable to employees below the senior executive level. Honda are the only company not to do so, apart from the inclusion of non-monetary initiatives.

Figure 81: Climate-related remuneration(i)



(i) Scored out of 100 where companies with higher scores receive higher rankings
Source: CDP, company reports

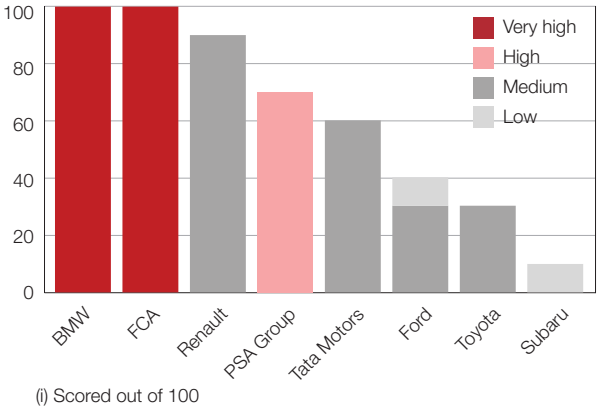
Figure 82: Overall board & executive climate responsibility(i)



Board level climate responsibility and expertise

- As shown in Figure 82, all of the 16 companies reported either a board or executive level standalone committee with responsibility for climate change (best performing companies reported separate committees at both levels). Four out of the 16 companies have a board-level committee (FCA, Ford, General Motors and Tata Motors), 15 reported to have an executive-level committee, and three companies operate committees at both board and executive levels (FCA, Ford and Tata Motors).
- FCA rank first for this metric, with one climate-experienced director on its board and separate climate-relevant committees at both board (Governance and Sustainability Committee) and executive levels (Cross-functional Sustainability Committee), coupled with strong integration of climate-related issues into its overall risk management framework.
- Honda and Subaru rank in the bottom two. Both companies exhibit below-average performance on climate-related committees and climate-related risk management frameworks. We find Subaru to have a director with limited climate-experience and Honda to have no climate-experienced directors.
- Eight out of the 16 companies were found to have a director on their board with varying degrees of climate-relevant professional experience. BMW and FCA were each found to have a single climate-experienced director on their board considered to be at a 'very high' level (Figure 83).

Figure 83: Overall climate experienced director's performance(i)



(i) Scored out of 100
Source: CDP, company reports

Water withdrawal intensity and management

- While OEMs do not withdraw and consume water on the scale of other industries, it is used throughout the production process and is essential to the continuity of operations. Figure 84 shows that all companies within the sample have reduced their water withdrawal intensities since 2010.
- FCA ranks first. The company was awarded an A grade in the 2017 CDP water questionnaire, and it has a low withdrawal intensity which it has reduced the second quickest since 2010.
- Suzuki has the lowest current intensity level closely followed by BMW and Toyota. Mazda has the highest intensity level but has reduced this by a significant 10.6% per annum, demonstrating good water management.
- Six of the 16 companies achieve an A grade in the 2017 questionnaire response. However, four companies - Daimler, Hyundai, PSA Group and Tata Motors - did not respond to the 2017 request.

Figure 84: Water withdrawal intensity

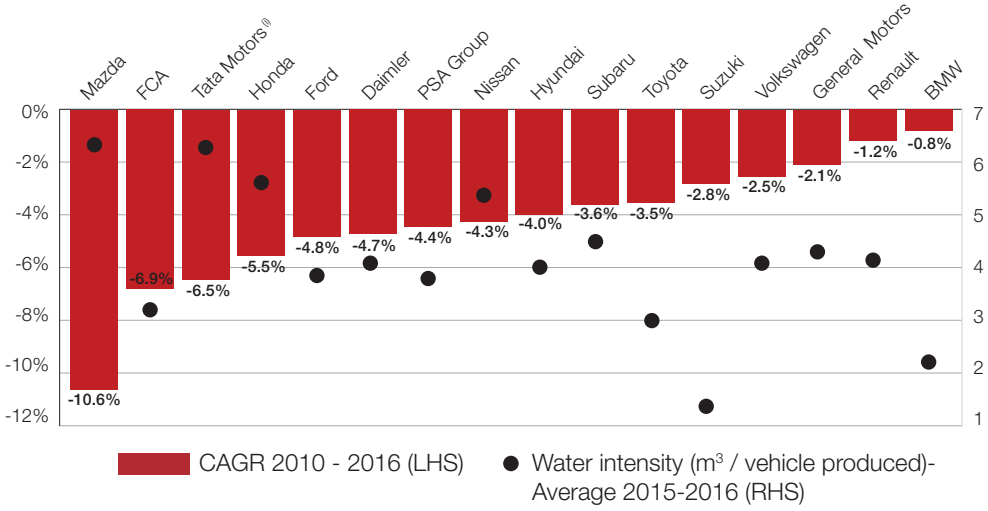


Figure 85: CDP 2017 water score

Company	CDP 2017 water score
Ford	A
Volkswagen	A
General Motors	A
FCA	A
Toyota	A
Nissan	A
BMW	A
Mazda	A-
Honda	B
Renault	B
Suzuki	C
Subaru	D-
Tata Motors (ii)	Not scored
Daimler (iii)	F
Hyundai (iii)	F
PSA Group (iii)	F

(i) Weighted average of Tata Motors Limited (TML) and Jaguar Land Rover (JLR) data. We note significant difference in performance: TML CAGR +1% vs. -6.3% for JLR.
(ii) Tata Motors did not respond to the CDP water questionnaire; however, no response was requested from Jaguar Land Rover.
(iii) Companies who are requested to disclose their data and fail to do so receive an F. An F does not indicate failure in environmental stewardship.
Source: CDP, company reports

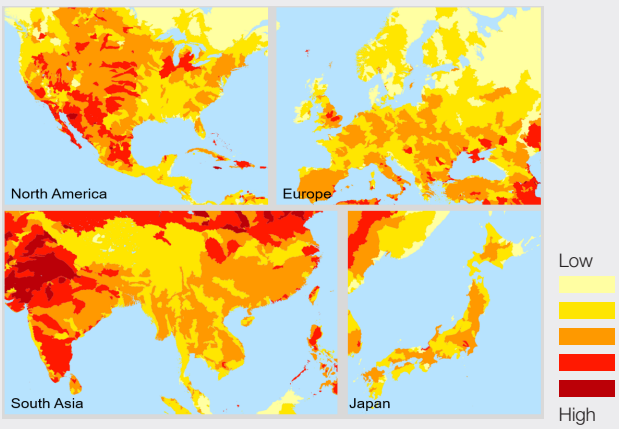
Physical risks – Water stress

OEM's will face increasing physical risks as a result of a changing climate. The TCFD categorize the physical impacts of climate change as acute near-term weather events, such as storms, floods and droughts and chronic long-term climatic changes, including sea-level rise or sustained heat-waves. Shifts in seasonal variability and an increase in the frequency and severity of extreme weather events has the potential to cause major disruptions to the continuity of automotive manufacturing and material attainment through supply chains.

Water stress, defined as a "lack of sufficient water to meet human and ecological demands, encompassing water scarcity as well as water accessibility, water quality and environmental flows"[75] is a significant physical risk faced by OEMs. Water is used throughout the manufacturing and assembly process; in cooling, cleaning, surface treatment and coating, as well as at every point in the vehicles life cycle, from material extraction to end-of-life recycling. Companies have extensive supply chains, often in countries where costs are lower but experience greater unpredictability in weather patterns and higher water stress. Therefore, maintaining a consistent and high quality water supply is vital.[76] OEMs should take a long-term view in managing water resources at manufacturing facilities to avoid future production issues and unforeseen costs.

Figure 86 is taken from the World Resource Institute Aqueduct water-stress mapping tool and shows water stress in four key car markets and manufacturing locations. The tool considers several water stress indicators including physical water quantity and quality and regulatory and reputational risks and assigns a risk category to distinct river basins. Several regions within the US and India are already under high water stress, while large regions of China, Europe and Japan are deemed to be at medium to high water stress risk. With continued pressures from competing industries and population growth, water stress is likely to worsen in many of these regions. An analysis of water indicators using water mapping tools such as Aqueduct should therefore be incorporated into OEMs' water management procedures.

Figure 86: Current water stress levels



Source: World Resource Institute

75. Mueller S. et al. 2015, Requirements for water assessment tools: An automotive industry perspective, Water Resource and Industry
76. PwC. 2017, Water in industry, https://www.pwc.com/gx/en/services/sustainability/water/industry.html

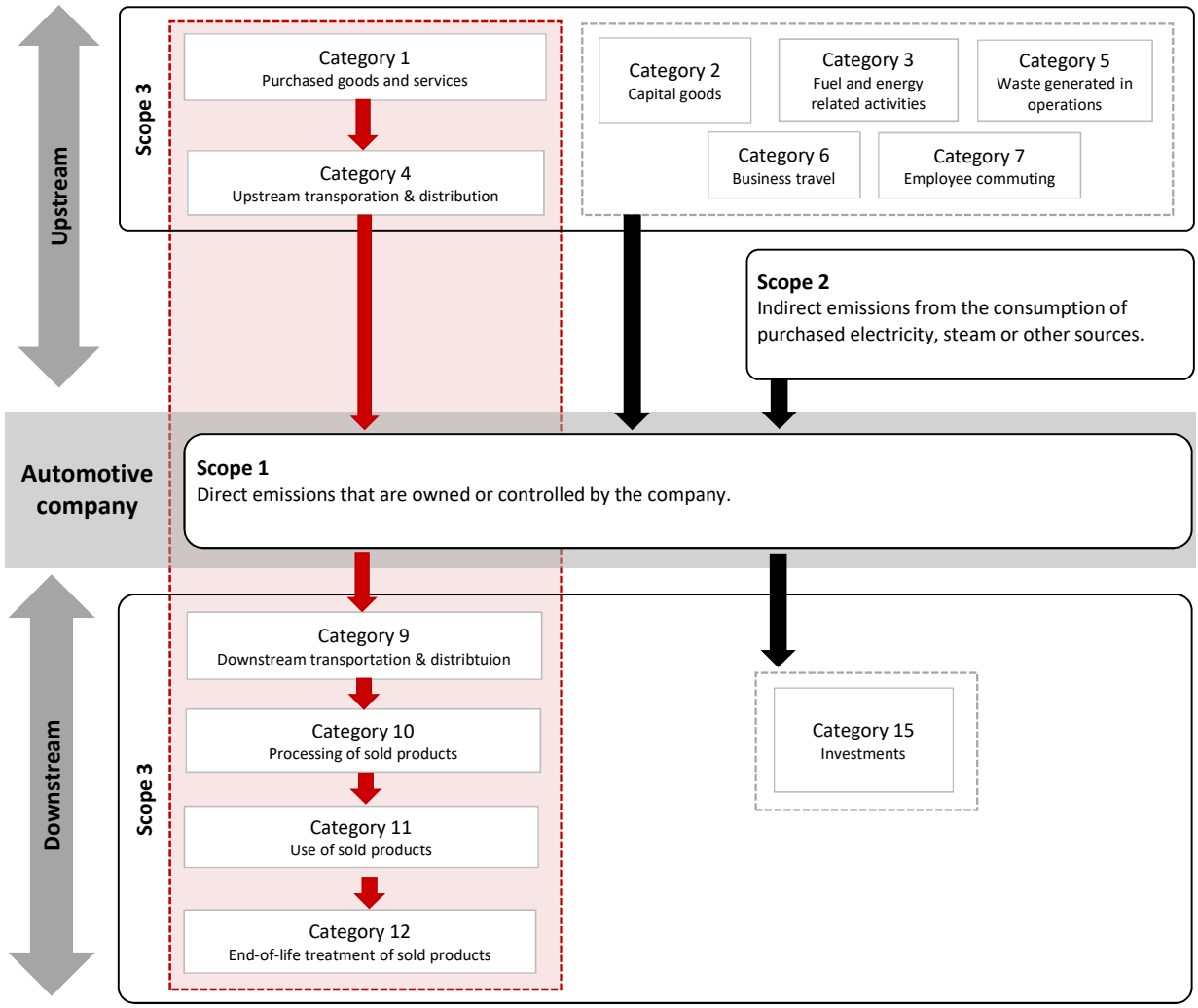
Supplementary figures

Figure 87: Summary of country policy support for Electric and Autonomous vehicles:

Country or Region	Policy Support for Electric Vehicles	Policy Support for Autonomous Driving Vehicles
China	**(1)** Plans to ban the sale of diesel and petrol vehicles in the near future; **(2)** Plan to increase the sale of advanced vehicles from 507,000 in 2017 to 7m by 2025. **(3)** Plans to introduce new-energy vehicle (NEV) share mandates of 10% for 2019 and 12% for 2020.	**(1)** The government have plans for Level 2-3 vehicles to account for 50% of all auto sales by 2020, Level 4 vehicles to account for 15% of sales by 2025 and Level 5 vehicles to account for 10% of all sales by 2030.
France	**(1)** Ban the sale of all diesel and petrol vehicles from 2040; **(2)** Car registration tax exemptions / deductions for advanced vehicles (decision devolved to regional governments); **(3)** A €10,000 grant towards a new EV when an 'old' diesel or LCV is scrapped.	**(1)** As part of the "New Industrial France" strategy the government are allowing manufacturers to test ADVs on public roads; **(2)** The French government have also invested in EasyMile to create a fully autonomous shuttle bus service.
Germany	**(1)** Ten-year exemption from road tax for new EVs; **(2)** Government subsidies for EVs (€4,000) and hybrids (€3,000).	**(1)** In 2017 legislation was passed to allow for the testing of ADVs on public roads.
India	**(1)** Full electrification of vehicle sales by 2030.	No evidence of support
Japan	**(1)** Battery capacity and electric range-based purchase subsidy.	**(1)** Japan plan to deploy a fleet of ADVs for the 2020 Tokyo Olympic Games and have invested heavily in 3D / dynamic mapping of Tokyo with plans to extend this to the rest of the country post-2020.
Netherlands	**(1)** Tax exemptions for PHEVs and EVs; **(2)** Discounted income tax levied on ZEVs; **(3)** By 2030 all new vehicle sales will be ZEVs.	**(1)** In 2017 the government adopted a bill that would allow the testing of ADVs where no physical driver is required to be present.
Norway	**(1)** All new private cars, city buses and light cars to be ZEVs by 2025; **(2)** Plan to halve transport emissions by 2030; **(3)** All HGVs, 75% of intercity buses and 50% of new trucks to be ZEVs by 2030.	**(1)** Introduction of legislation to allow for testing of ADVs on public roads.
Poland	**(1)** Aim for a stock of 1 million EVs by 2025.	**(1)** The government has signaled their support for ADVs but have not yet concrete policy proposals.
South Korea	**(1)** Generous state subsidies for selected EVs (up to $12,000);	**(1)** SK government (MLIT) is investing $9.7m in building K-City, the world's largest ADV testing site (88-acres).
United Kingdom	**(1)** Plan to ban the sale of all diesel and petrol vehicles by 2040; **(2)** £400m of investment in EV recharging infrastructure; **(3)** £100m in additional funding for the 'Plug-in car' grant scheme.	**(1)** Creation of the Centre for Connected and Autonomous Vehicles (CCAV) to support the development and deployment of ADVs and looking to support ADV testing on UK roads by 2021; **(2)** Delivering programme of R&D, demos and deployment worth up to £200m; **(3)** Development of a formal code of practice to provide regulatory certainty to companies wishing to test ADVs in the UK.
United States	EV support is mostly devolved to state governments with the level of support varying considerably: **(1)** Ten states have ZEV mandates which require a minimum % of OEM sales to be ZEVs; **(2)** In some states, subsidies and tax exemptions are available.	**(1)** $3.9bn committed to financing projects that support the development of ADVs; **(2)** Relaxation of regulatory guidelines for ADV testing increasing the freedom of companies to test ADV vehicles.

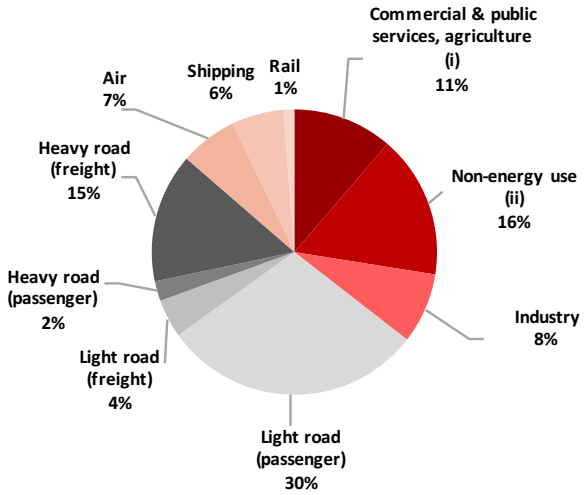
Source: IEA, government reports, press releases

Figure 88: Emissions categories



Source: CDP, GHG protocol

Figure 89: Road transport currently accounts for more than 50% of oil consumption



(i) Also includes residential and non-specified other.
(ii) Non-energy use covers fuels used as raw materials in different sectors e.g. petrochemical feedstock.
Source: IEA ETP 2017, IEA Key World energy statistics 2016

Company performance overview

	League Table rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Weighting	
	Companies	**BMW**	**Daimler**	**Toyota**	**Nissan**	**Honda**	**Volkswagen**	**Renault**	**Tata Motors**	**PSA Group**	**Ford**	**Mazda**	**General Motors**	**Hyundai**	**Suzuki**	**FCA**	**Subaru**	***Metric***	***Area***
	Transition risks rank	**6**	**2**	**4**	**7**	**3**	**12**	**9**	**1**	**8**	**14**	**5**	**16**	**13**	**11**	**15**	**10**		**40%**
Transition risks	Fleet emissions (EU)	7	4	2	3	13	8	6	1	5	9	12	n/a	14	10	15	11	70%(i)	
	Fleet emissions (US)	8	5	7	2	4	12	n/a	n/a	n/a	10	1	9	6	n/a	11	3		
	Fleet emissions (China)	2	1	6	11	5	8	12	14	7	13	3	16	10	9	15	4		
	Fleet emissions (Japan)	n/a	n/a	2	3	1	n/a	n/a	n/a	n/a	n/a	4	n/a	n/a	5	n/a	6		
	Manufacturing emissions & energy	3	4	10	16	6	14	11	9	7	2	1	15	8	13	5	12	10%	
	Business resilience	6	1	2	13	9	7	11	3	12	16	10	15	8	4	5	14	20%	
	Transition opportunities rank	**3**	**5**	**8**	**4**	**9**	**2**	**10**	**11**	**12**	**6**	**15**	**1**	**7**	**16**	**13**	**14**		**40%**
Transition opportunities	Advanced vehicles (Market share ratio)	2	4	1	3	5	10	9	16	12	7	15	8	6	13	11	14	15%	
	Advanced vehicles (Technical review)	8	7	3	9	2	5	11	14	12	6	13	4	1	16	10	15	12.5%	
	Advanced vehicles (Targets)	3	2	7	8	11	1	8	4	6	8	14	5	12	14	13	14	12.5%	
	Advanced vehicles (Patents filed)	9	11	2	1	3	14	10	12	16	8	13	6	4	5	15	7	10%	
	ADVs & MaaS (Investment & acquisitions)	5	2	7	11	9	6	10	8	12	4	12	3	1	12	12	12	8%	
	ADVs & MaaS (Partnerships & services)	7	2	3	7	13	1	10	11	3	7	14	12	5	14	5	14	6%	
	ADVs & MaaS (targets)	4	8	12	2	10	4	3	14	9	4	11	1	4	15	12	15	12%	
	ADVs & MaaS (Patents / road tests)	5	6	10	4	8	3	9	11	11	2	11	1	11	11	11	7	14%	
	R&D	3	7	12	9	4	1	8	2	10	6	13	5	16	11	15	14	5%	
	Renewable energy	2	8	12	11	10	6	4	1	9	5	15	7	13	16	3	14	5%	
	Climate governance & strategy rank	**2**	**6**	**3**	**5**	**13**	**8**	**1**	**9**	**7**	**11**	**10**	**12**	**15**	**14**	**4**	**16**		**20%**
Climate governance & strategy	Supplier engagement & LCA	8	6	2	7	9	5	3	10	13	12	4	11	15	14	1	16	25%	
	Emissions targets	5	8	1	2	4	7	6	10	9	11	3	13	14	12	15	16	25%	
	Data assurance	2	8	11	9	6	4	1	12	7	10	14	5	13	16	3	15	5%	
	Use of internal carbon price	3	4	10	4	10	4	4	2	10	13	4	1	13	13	4	13	5%	
	Remuneration	3	4	12	10	10	9	2	8	1	5	14	7	12	15	5	15	15%	
	Board level expertise	3	10	9	13	16	8	6	2	5	4	11	7	13	12	1	15	10%	
	Water management	11	13	4	6	7	5	16	9	14	2	3	8	15	10	1	12	10%	
	CDP Score	1	4	2	7	11	8	5	14	9	10	12	3	13	16	5	15	5%	
Total	Green	10	5	10	6	5	6	4	7	3	5	5	5	3	0	4	2		
	Yellow	10	14	5	9	6	10	8	5	6	11	4	8	5	5	8	0		
	Orange	3	2	8	7	10	4	8	5	8	5	5	6	5	4	2	5		
	Red	0	2	1	2	3	3	2	5	5	2	10	3	10	14	9	17		

(i) Weighting varies based on OEM's sales exposure to each market
Source: CDP

This heat map is designed to help investors pinpoint priority areas for engagement.

Green = good performance
Yellow = reasonable performance
Orange = monitor performance, possible concern
Red = area of concern, engage with company

We have not assigned a uniform number of green, yellow, orange and red colours across the metrics according to rank. Instead, we have reviewed the results of each metric in detail and assigned the above colours according to the underlying values for each metric.

Appendix II: Company summaries

Subaru

Country: Japan

Average market cap 2017: US$ 28 bn

Unit sales, global market share (2016 - Q3 2017): 1%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
7270 JP	16 / 16	10	14	16

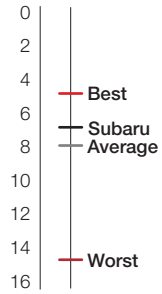
Company strengths

- Has the highest EBIT margin of all the OEMs, affording it more room to manoeuvre in a low-carbon transition.
- Ranks third on fleet emissions performance in the US and fourth in China. However, an increased emissions reduction rate is still required to meet regulatory targets in China.
- Successful sales of hybrid vehicles and looking to launch PHEV end of 2018 and BEV in 2021.
- Leads on number of 'world class' Li-ion battery patents per employee and also ranks well for autonomous patents.

Company weaknesses

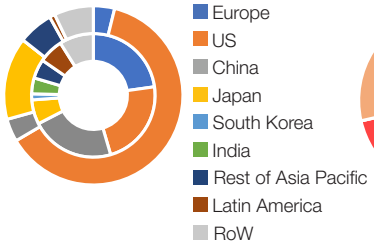
- Ranks last for climate governance & strategy. Shows little sign of engaging suppliers on climate-related issues, has weak emissions reduction targets (no Scope 3 target), poor emissions data verification and no evidence of climate-related remuneration.
- Poor fleet emissions performance in the EU and Japan. Increased emissions reduction rates are required to meet 2020/2021 targets. Is the only OEM in danger of missing the Japanese target and is at risk of having to pay regulatory fines in the EU.
- Unlike other OEMs it has not communicated an automation target and there is little evidence of investment in ADVs and MaaS.

Fleet emissions weighted rank

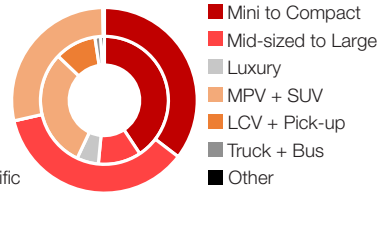


Sales by region

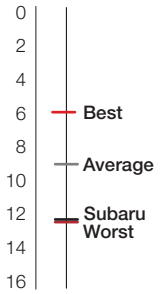
Outer circle: Subaru
Inner circle: Average for 16 OEMs



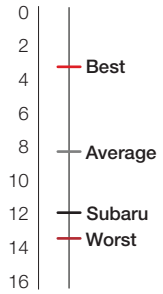
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



FCA

Country: Italy / USA

Average market cap 2017: US$ 20 bn

Unit sales, global market share (2016 - Q3 2017): 5%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
FCAU US	15 / 16	15	13	4

Company strengths

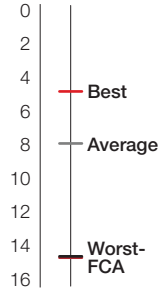
- Strong supplier engagement and conduct LCA – incorporating the concept of a 'circular economy' into business approach.
- Components / parts business (8% of revenue) and luxury vehicle sales (9%) provide some resilience to disruptive market forces.(i)
- Has a relatively ambitious renewable energy target (CAGR of 10%). However, it is not a member of the RE100 initiative.
- Low water withdrawal intensity (3.1 m^3 / vehicle produced) which it has reduced second quickest since 2010.

(i) We note that FCA plans to spin-off component businesses Magneti Marelli and Comau by 2019.

Company weaknesses

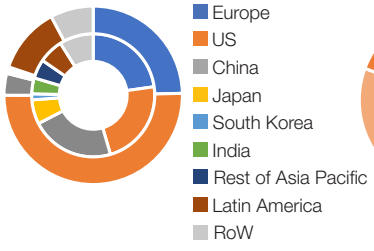
- Poor fleet emissions performance. For the EU, US and China, an increased rate of emissions reduction is required to meet 2020/21 targets. Is at risk of having to pay significant regulatory fines in the EU.
- Lags behind competitors in areas of ADVs and MaaS. It does not go beyond a Level 3 automation target for 2020 and there is little evidence of active investment in these capabilities. However, it does have partnerships with Intel & Mobileye and Waymo for ADVs.
- Is only taking small steps towards electrification in comparison to other OEMs.
- Comparatively weak emissions reduction targets.

Fleet emissions weighted rank

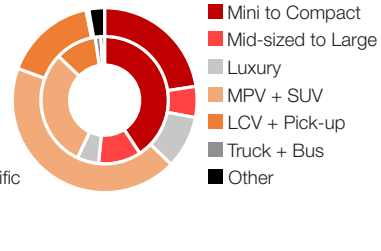


Sales by region

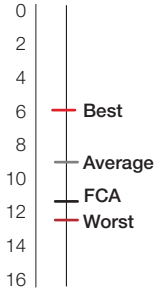
Outer circle: FCA
Inner circle: Average for 16 OEMs



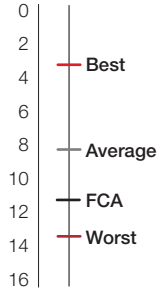
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Suzuki

Country: Japan

Average market cap 2017: US$ 23 bn

Unit sales, global market share (2016 - Q3 2017): 3%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
7269 JP	14 / 16	11	16	14

Company strengths

- Ranks fourth for business resilience - motorcycle business and marine products provide good diversification and it should benefit from its exposure to growth markets such as India and Southeast Asia.
- Has significantly reduced fleet emissions in Japan since 2012 (at 5.3% p.a.) and is already very close to beating its 2020 target.
- Second lowest manufacturing emissions and energy intensities. However, it is the only OEM where these intensities have increased since 2010.

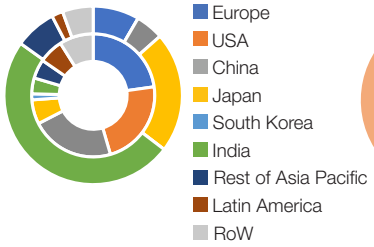
Company weaknesses

- Ranks second from last in transition opportunities. Shows little evidence of active investment in ADVs and MaaS. Unlike other OEMs it has not communicated an automation target and its only activity in this area is a partnership with SB Drive, looking at smart mobility services and ADV technologies.
- Lags competitors in development of advanced vehicles. However, has upcoming plan to launch its first electric vehicle in India in 2020.
- Requires an increased rate of reduction to meet fleet emissions targets in the EU and China.
- Ranks poorly for climate governance & strategy. Has weak emissions reduction targets, lacks climate-related remuneration and does not use an internal CO_2 price.

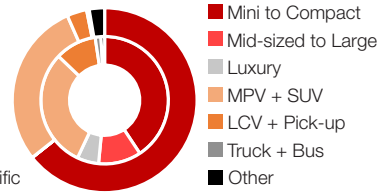
Fleet emissions weighted rank

Sales by region

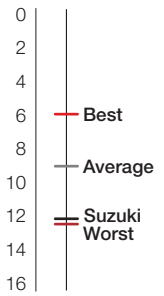
Outer circle: Suzuki
Inner circle: Average for 16 OEMs



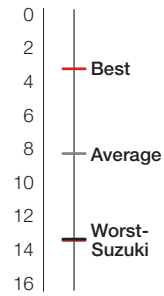
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Hyundai

Country: South Korea

Average market cap 2017: US$ 30 bn

Unit sales, global market share (2016 - Q3 2017): 5%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
005380 KS	13 / 16	13	7	15

Company strengths

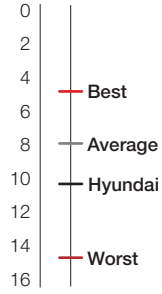
- Ranks first in our technical review of advanced vehicles. The Ioniq Electric achieves the top rank for BEVs. It has the best efficiency (15.4 kWh / 100km) and is competitive on both price and range. The PHEV model also performs strongly. Its focus on FCVs could pay off if the technology scales up.
- Investing in ADVs and MaaS – have devoted $2bn over 5-year period to develop ADV technology. Has its own car-sharing business Dealcar and through its recent partnership with Aurora is aiming for Level 4 autonomy by 2021.(i)
- Its railway business (7% of revenue) and exposure to emerging markets such as India provides some diversification and resilience to disruptive change.

Company weaknesses

- Poor fleet emissions performance. For the EU, US and China, an increased rate of emissions reduction is required to meet 2020/21 targets. Is at risk of having to pay significant regulatory fines in the EU.
- Advanced vehicle target is less ambitious than peers (has no specific sales / volume target).
- Has the lowest R&D as % of sales.
- Ranks second last for governance and strategy. Has poor supplier engagement, weak emissions reduction targets and a lack of climate-related remuneration.

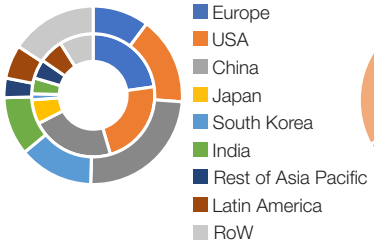
(i) We note its recent pledge to invest $22 bn over the next 5 years in EVs, ADVs and other technology (includes affiliate Kia).

Fleet emissions weighted rank

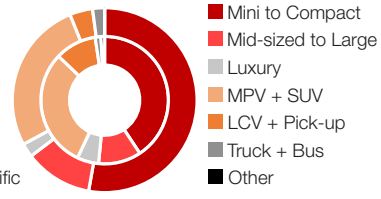


Sales by region

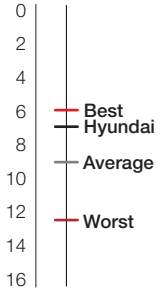
Outer circle: Hyundai
Inner circle: Average for 16 OEMs



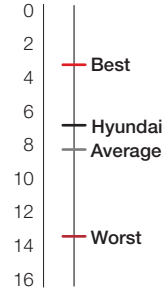
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



General Motors

Country: USA

Average market cap 2017: US$ 56 bn

Unit sales, global market share (2016 - Q3 2017): 9%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
GM US	12 / 16	16	1	12

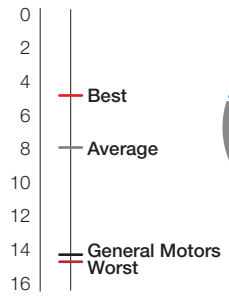
Company strengths

- Ranks first for transition opportunities.
- It is working towards "an all-electric future" and targets 1 million electric vehicle sales by 2026.
- It has the most ambitious automation target, looking to roll-out a fully self-driving ridesharing service by 2019 (Level 4 autonomy). It has invested significant amounts in ADVs and MaaS (c.$1bn for acquisition of Cruise and $500m investment in Lyft) and has the most ADV 'world-class' patents.
- Has a relatively ambitious renewable energy target and is a member of the RE100 initiative.

Company weaknesses

- Ranks last for managing transition risks.
- Poor fleet emissions performance in both the USA and China. Significant reductions are required to meet future targets. In China its fleet fuel consumption for JV and imported vehicles increased over the 2013-2016 period.
- Less business resilience to disruptive forces than peers due to lack of diversification and lower exposure to emerging markets.
- Only company to show little evidence of conducting in depth life-cycle analysis and emissions reduction targets are less ambitious than peers.

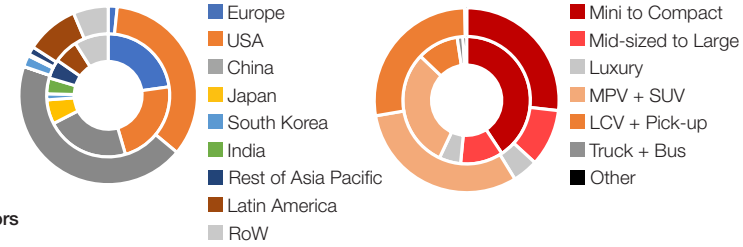
Fleet emissions weighted rank



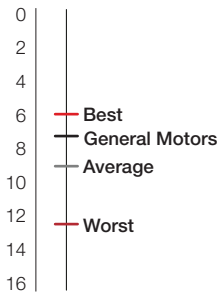
Sales by region

Sales by type

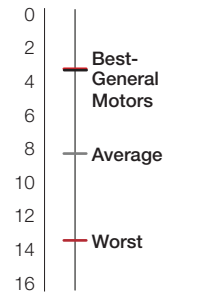
Outer circle: General Motors
Inner circle: Average for 16 OEMs



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Mazda

Country: Japan

Average market cap 2017: US$ 9 bn

Unit sales, global market share (2016 - Q3 2017): 2%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
7261 JP	11 / 16	5	15	10

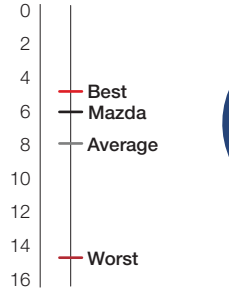
Company strengths

- Strong fleet emissions performance in US, China and Japan. Its US fleet emissions are amongst the lowest and it is already very close to beating its 2020 target in Japan.
- Has strong emissions reduction targets, engages with suppliers and conducts in depth life-cycle analysis. With its "Sustainable Zoom-Zoom 2030" strategy it aims to reduce 'well-to-wheel' CO_2 emissions to 50% of 2010 levels by 2030, and a 90% reduction by 2050.
- Likely to benefit from its exposure to growth markets such as Southeast Asia.
- Since 2010, it has reduced energy and water withdrawal intensities the quickest.

Company weaknesses

- Relatively poor fleet emissions performance in EU and is at risk of having to pay regulatory fines. Requires a reduction rate of 5.9% p.a. to meet its 2021 target (achieved reduction of 3.1% p.a. 2010-2016). However, we note that in 2019 it will be introducing its new SKYACTIV-X compression ignition technology which could be up to 30% more fuel-efficient.
- Ranks second last for transition opportunities. Has been less active in areas of advanced vehicles, ADVs and MaaS. However, its new partnership with Toyota looks to focus on these areas. No formal EV targets but is planning to launch a BEV in 2019 and PHEV in 2021.
- Has third lowest EBIT margin of company sample (4.9%).

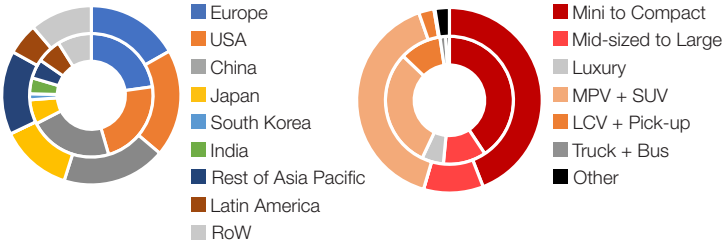
Fleet emissions weighted rank



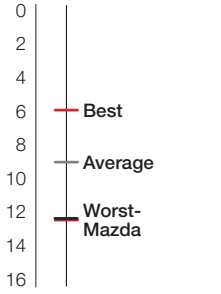
Sales by region

Sales by type

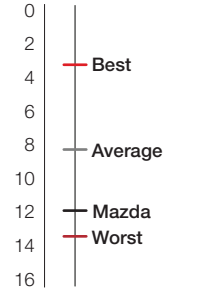
Outer circle: Mazda
Inner circle: Average for 16 OEMs



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Ford

Country: USA

Average market cap 2017: US$ 47 bn

Unit sales, global market share (2016 - Q3 2017): 7%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
F US	10/16	14	6	11

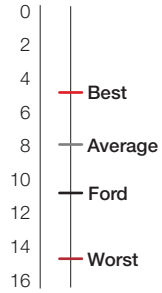
Company strengths

- Active in ADVs – has high number of world class patents and the second lowest number of disengagements per 1000km for ADV road-tests. Has invested $1bn in Argo AI and a strategic partnership with Lyft. Is targeting Level 4 autonomy by 2021.
- Since 2010 has reduced manufacturing emissions, energy and water withdrawal intensities at relatively fast rate compared with other OEMs.
- Third highest proportion of energy consumption from renewables (20%). However, currently no renewable energy target and not a member of the RE100 initiative.

Company weaknesses

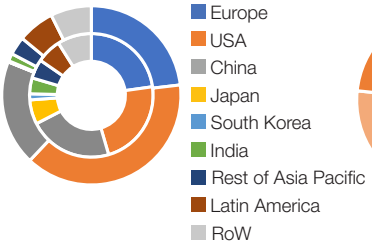
- Poor fleet emissions performance across all regions. For EU, US and China an increased rate of emissions reduction is required to meet 2020/21 targets. At risk of having to pay significant regulatory fines in the EU.
- Ranks last for business resilience – lacks diversification, has lower exposure to emerging markets than others, has low share of sales from luxury vehicles (2%), and second lowest EBIT margin (4.7%).
- Scope 1, 2 & 3 emissions reduction targets are not as aggressive as other OEMs.

Fleet emissions weighted rank

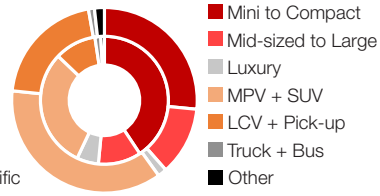


Sales by region

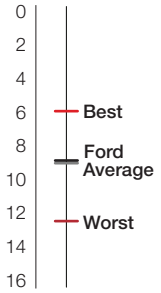
Outer circle: Ford
Inner circle: Average for 16 OEMs



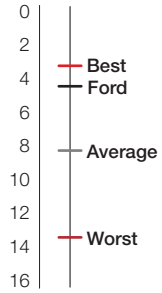
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



PSA Group

Country: France

Average market cap 2017: US$ 19 bn

Unit sales, global market share (2016 - Q3 2017): 4%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
UG FP	9/16	8	12	7

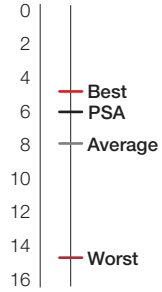
Company strengths

- Strong EU fleet emissions performance. Has significantly reduced fleet emissions since 2010 (4.3% p.a.). However, now faces bigger challenge to meet 2021 targets with the acquisition of Opel.
- Ranks first for climate-related remuneration (5% of exec bonus linked to CO_2 emissions reduction) and has climate expertise at board level.
- Has the lowest manufacturing emissions intensity (0.28 tCO_2/vehicle produced).

Company weaknesses

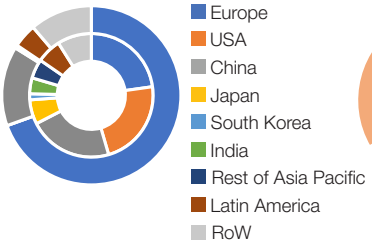
- Has lagged other OEMs in capturing advanced vehicle market (BEV market share ratio 0.36). However, new EV models to be launched 2019 and targets 80% of models offered to be electrified in 2023.
- Compared to peers its Level 4 automation target for 2025 is less ambitious.
- Ranks lower on supplier engagement compared to other OEMs (suppliers engaged as % of total spend: 22%) and emissions reduction targets are less aggressive than peers.

Fleet emissions weighted rank

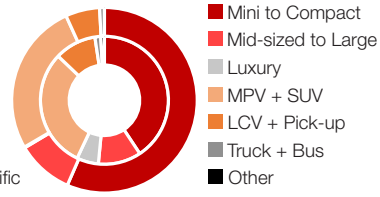


Sales by region

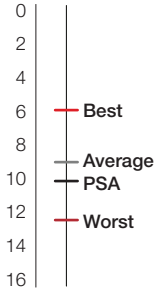
Outer circle: PSA Group
Inner circle: Average for 16 OEMs



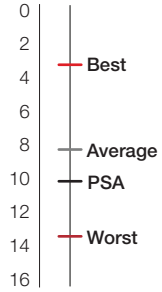
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Tata Motors[(i)]

Country: India / UK

Average market cap 2017: US$ 22 bn

Unit sales, global market share (2016 - Q3 2017): 1%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
TTMT IN	8 / 16	1	11	9

Company strengths

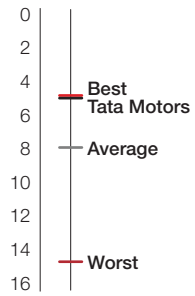
- Ranks first for managing transition risks. Has significantly reduced Jaguar Land Rover (JLR) fleet emissions in the EU and its exposure to emerging markets, luxury vehicles and trucks may provide some resilience to disruptive technologies.
- Relatively ambitious EV target from JLR (every vehicle launched from 2020 will be electrified). A notable entry to the market is the I-Pace, Jaguar Land Rover's first BEV, which looks set to challenge the Tesla Model X.
- Has a significant proportion of energy consumption sourced from renewables (JLR currently source 90% of electricity from renewables) and has an aggressive renewable energy target.

Company weaknesses

- Unlike other OEMs it has not communicated an ADV target date but we note JLR are researching ADVs with 'Sayer' and its FUTURE-TYPE concept.
- Has lagged behind other OEMs on entering advanced vehicle markets.
- Less ambitious emissions reduction targets than peers with emissions intensity targets only (no absolute targets).
- Fewer strategic partnerships than peers in the areas of ADVs and MaaS (but we note it has a number of investments through JLR's venture InMotion).

(i) Analysis for Tata Motors includes fully owned subsidiary Jaguar Land Rover.

Fleet emissions weighted rank

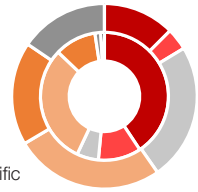


Sales by region

Outer circle: Tata Motors
Inner circle: Average for 16 OEMs

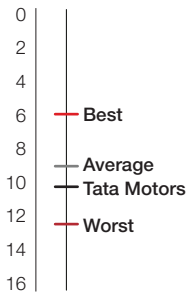
Europe
USA
China
Japan
South Korea
India
Rest of Asia Pacific
Latin America
RoW

Sales by type

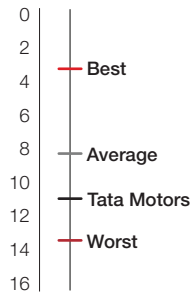


Mini to Compact
Mid-sized to Large
Luxury
MPV + SUV
LCV + Pick-up
Truck + Bus
Other

Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Renault

Country: France

Average market cap 2017: US$ 28 bn

Unit sales, global market share (2016 - Q3 2017): 3%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
RNO EU	7 / 16	9	10	1

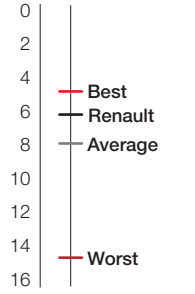
Company strengths

- Ranks first for governance & strategy. Has strong supplier engagement, conducts comprehensive LCA, and has climate-related remuneration at exec level.
- Has good exposure to emerging markets (approx. 40% of vehicle sales) which should provide some resilience to disruptive forces.
- Has led European BEV market with Renault Zoe (BEV market share ratio of 1.6) but advanced vehicle targets are less ambitious than others.
- Strong ADV targets, targeting Level 5 by 2022.

Company weaknesses

- Less activity in MaaS than peers (disclosed investment is lower than other OEMs and has fewer strategic partnerships.)
- Has not reduced manufacturing emissions and energy intensity as quickly as others since 2010.
- Requires a fleet emissions reduction rate of 7.3% p.a. for JV passenger vehicles to meet its 2020 target in China.
- Lack of diversification with no revenue outside core automotive business and no luxury positioning.

Fleet emissions weighted rank

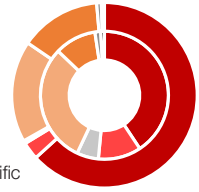


Sales by region

Outer circle: Renault
Inner circle: Average for 16 OEMs

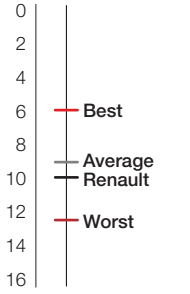
Europe
USA
China
Japan
South Korea
India
Rest of Asia Pacific
Latin America
RoW

Sales by type

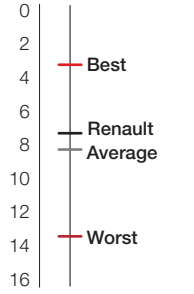


Mini to Compact
Mid-sized to Large
Luxury
MPV + SUV
LCV + Pick-up
Truck + Bus
Other

Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Volkswagen

Country: Germany

Average market cap 2017: US$ 82 bn

Unit sales, global market share (2016 - Q3 2017): 11%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
VOW GR	6 / 16	12	2	8

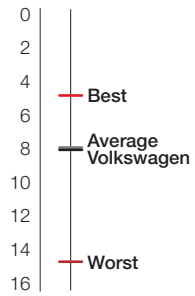
Company strengths

- Ranks second for transition opportunities. In our view it has the most aggressive EV target, which sees up to 25% of sales from BEVs by 2025 (50 new BEV and 30 new PHEV models, with electric versions of all models by 2030).
- Strong market position in China where it is investing €10 bn to develop EVs.
- Trucks (10% of revenue) and power engineering (2% of revenue) businesses provide some diversification and resilience to disruptive forces.
- Highest R&D as % of sales and highest number of partnerships and company services dedicated to developing ADVs and MaaS capabilities.

Company weaknesses

- Still feeling the effects of the emissions scandal (estimates put total cost to company so far at around $30bn). For both the EU and China, an increased rate of emissions reduction is required to meet 2020/21 targets. With the new WLTP testing procedure, focus needs to be on reducing emissions under real-world driving conditions.
- Has the second highest manufacturing emissions intensity (0.88 tCO_2/vehicle produced) and has not reduced manufacturing emissions and energy intensity as quickly as others since 2010.
- Fewer world class patents per employee for EVs than peers and no world class patents in Li-ion battery technology according to the Bakbasel study.

Fleet emissions weighted rank

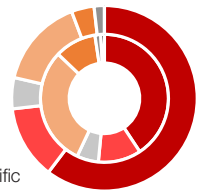


Sales by region

Outer circle: Volkswagen
Inner circle: Average for 16 OEMs

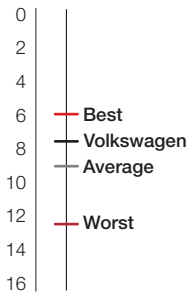
Europe
USA
China
Japan
South Korea
India
Rest of Asia Pacific
Latin America
RoW

Sales by type

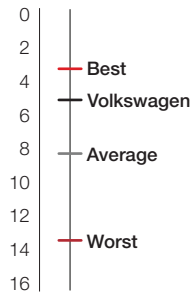


Mini to Compact
Mid-sized to Large
Luxury
MPV + SUV
LCV + Pick-up
Truck + Bus
Other

Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Honda

Country: Japan

Average market cap 2017: US$ 54 bn

Unit sales, global market share (2016 - Q3 2017): 5%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
7267 JP	5 / 16	3	9	13

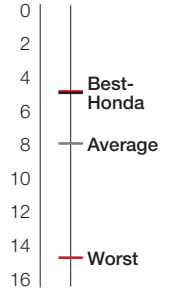
Company strengths

- Ranks first for overall fleet emissions performance. Has already significantly beaten 2020 target in Japan and has fourth strongest performance in the US.
- Motorcycle business provides good diversification and it will benefit from its exposure to growth markets such as Southeast Asia.
- Ranks second for advanced vehicles. Has market share ratios greater than 1.0 for FCVs and HEVs. FCV positioning could pay off if technology scales up. Its Clarity BEV, FCV and PHEV models perform well in our technical review and it has a high number of world class EV patents per employee.

Company weaknesses

- Poor fleet emissions performance in EU where in 2021 it may incur regulatory fines (but exposure to market is low compared to other regions).
- Its advanced vehicle target (2/3 of sales electrified by 2030) lacks ambition compared to peers.
- Its Level 4 automation target for 2025 is less ambitious than some OEMs and it has fewer partnerships and less disclosed investment in the areas of ADVs and MaaS.
- Has lowest EBIT margin of company sample (4.5%).
- Only company to have no evidence of climate-related remuneration below senior executive level. Has no climate-experienced directors and is below-average for climate-related risk management frameworks.

Fleet emissions weighted rank

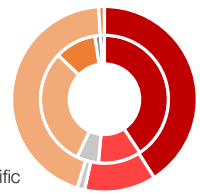


Sales by region

Outer circle: Honda
Inner circle: Average for 16 OEMs

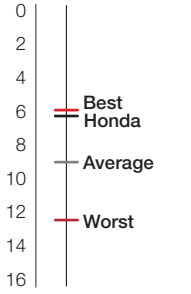
Europe
USA
China
Japan
South Korea
India
Rest of Asia Pacific
Latin America
RoW

Sales by type

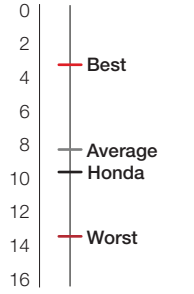


Mini to Compact
Mid-sized to Large
Luxury
MPV + SUV
LCV + Pick-up
Truck + Bus
Other

Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Nissan

Country: Japan

Average market cap 2017: US$ 42 bn

Unit sales, global market share (2016 - Q3 2017): 6%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
7201 JP	4 / 16	7	4	5

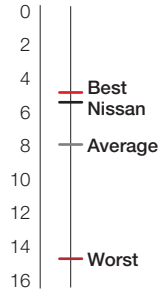
Company strengths

- Ranks third for overall fleet emissions performance. Has already beaten 2020 target in Japan, has the second strongest performance in US, and strongest LCV performance in EU. However, let down by poorer performance in China.
- High success with BEV Nissan Leaf (market share ratio of 4.2). The new Leaf model is well priced and has a good range (241km EPA), coming a close second in our technical review.
- Strong performance on innovation with high numbers of patents for FCVs, electric vehicles and Li-ion batteries. Fewer world class automation patents than peers but does have ambitious ADV target (Level 5 by 2022).

Company weaknesses

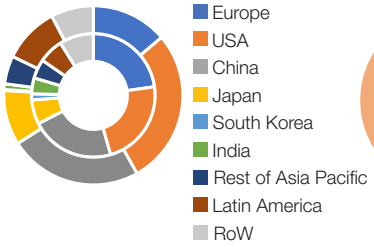
- Poor fleet emissions performance in China. JV fleet emissions have remained flat since 2013 and it requires reduction rates of 7.0% p.a. and 8.4% p.a. to meet 2020 targets for JV and imported vehicles respectively.
- Has not reduced manufacturing emissions and energy intensity as quickly as others since 2010.
- Ranks poorly for climate-related remuneration and climate-expertise (has no climate-experienced directors and exhibits below-average performance for climate-related committees).

Fleet emissions weighted rank

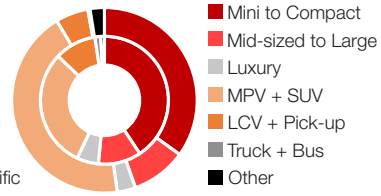


Sales by region

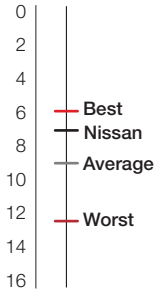
Outer circle: Nissan
Inner circle: Average for 16 OEMs



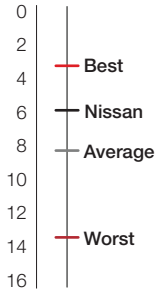
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Toyota

Country: Japan

Average market cap 2017: US$ 188 bn

Unit sales, global market share (2016 - Q3 2017): 11%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
7203 JP	3 / 16	4	8	3

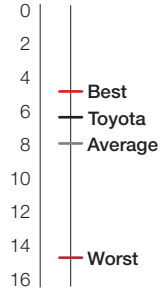
Company strengths

- Market share ratios greater than 1.0 for FCVs, PHEVs and HEVs. Has dominated HEV market with success of models such as Prius. FCV positioning could pay off if technology scales up. Recent EV target confirms Toyota plans more than 10 BEV models by early 2020s.
- Ranks first for emissions reduction targets and second for supplier engagement. Has comprehensive targets with its Environmental Challenge 2050, and conducts in depth LCA, looking to reach zero CO_2 emissions in the entire vehicle life cycle. Works closely with suppliers to achieve this through its 'Green Purchasing Guidelines'.
- Ranks second for business resilience. Has a relatively high EBIT margin (8.3%) and will benefit from its exposure to growth markets such as Southeast Asia.

Company weaknesses

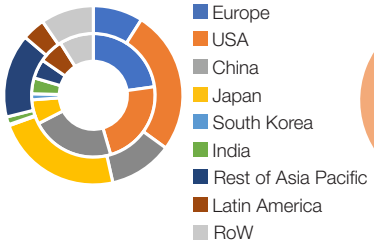
- Compared to peers its performance is average for ADVs. It does not go beyond a Level 3 automation target for 2020 and it has a lower number of world class ADV patents filed per employee. However, we note it has several partnerships and undisclosed investments in ADVs and MaaS, e.g. in Grab and Nauto.
- Only average performance for fleet emissions reduction in both the US and China. For the US an increased rate of emissions reduction is required to meet 2021 targets (performs well in EU and has already beaten its 2020 target in Japan).
- Current use of renewable energy is low and it is not a member of the RE100 initiative. Increasing its share of renewable energy would help to improve its manufacturing emissions intensity.

Fleet emissions weighted rank

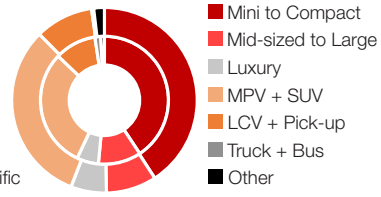


Sales by region

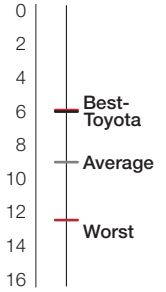
Outer circle: Toyota
Inner circle: Average for 16 OEMs



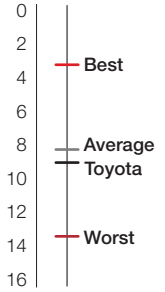
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Daimler

Country: Germany

Average market cap 2017: US$ 81 bn

Unit sales, global market share (2016 - Q3 2017): 3%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
DAI GR	2 / 16	2	5	6

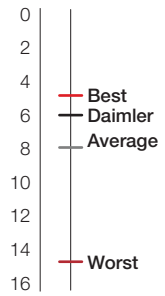
Company strengths

- Ranks first for business resilience. It is the world's largest truck manufacturer (21% of group revenue), has a high share of sales from luxury vehicles (24%) and a relatively high EBIT margin (9.1%).
- Very aggressive EV targets (25% of Mercedes sales from BEVs by 2025, electric versions of all cars by 2022). To be championed under new brand EQ.
- Strong positioning in MaaS with Mytaxi and Car2Go and strategic partnerships with Bosch and Uber for ADVs.

Company weaknesses

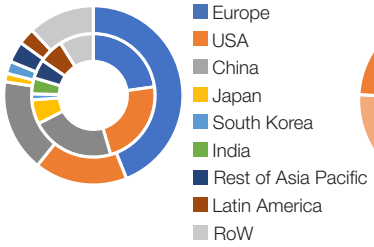
- Compared to peers its Level 4 automation target for 2023 is less ambitious and it has a higher number of disengagements per 1000km during ADV road-tests. However, we note it is taking the lead on autonomous trucks.
- Has the highest manufacturing emissions intensity (0.88 tCO_2/vehicle produced) and highest energy intensity (3.0 MWh / vehicle produced) of all the OEMs.
- Does not respond to CDP water questionnaire.

Fleet emissions weighted rank

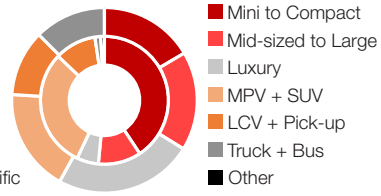


Sales by region

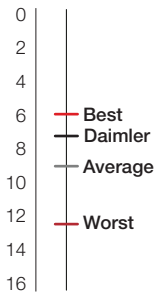
Outer circle: Daimler
Inner circle: Average for 16 OEMs



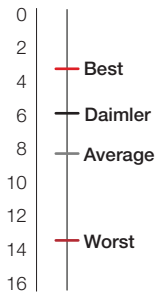
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



BMW

Country: Germany

Average market cap 2017: US$ 62 bn

Unit sales, global market share (2016 - Q3 2017): 2%

Ticker	League Table rank	Managing transition risks rank	Transition opportunities rank	Climate governance & strategy rank
BMW GR	1 / 16	6	3	2

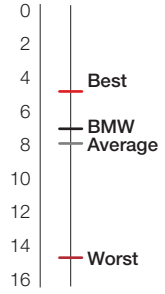
Company strengths

- Market share ratios greater than 1.0 for both BEVs and PHEVs due to success from i3 models. Relatively aggressive EV targets (15 – 25% of sales BEV / PHEV by 2025) with new models in the pipeline (such as Mini-E, X3-E, and the i-Next in 2021 which aims to feature Level 3/4 autonomy).
- Active in ADVs – has the lowest number of disengagements per 1000km for ADV road-tests. Partnership with Intel & Mobileye for open platform ADV development and invested $1bn in mapping business HERE. Exposure to MaaS through its companies DriveNow, ParkNow, ChargeNow and ReachNow.
- Ranks second for climate governance & strategy with strong emissions reduction targets which are linked to executive pay and has climate expertise at board level.

Company weaknesses

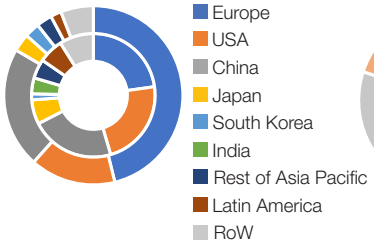
- Only average performance for fleet emissions reduction in both the US and EU. For both regions an increased rate of emissions reduction is required to meet 2021 targets (performs better in China).
- Lacks diversification; has lowest exposure to emerging markets, no mass market business, and only a very small amount of revenue outside the core automotive business (from motorbikes). However, its high share of sales from luxury vehicles (27%) and relatively high EBIT margin (10%) should provide some business resilience to disruptive changes.
- Has reduced water withdrawal intensity the least since 2010 (only 0.8% p.a.).

Fleet emissions weighted rank

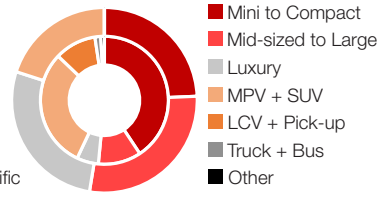


Sales by region

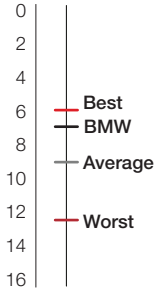
Outer circle: BMW
Inner circle: Average for 16 OEMs



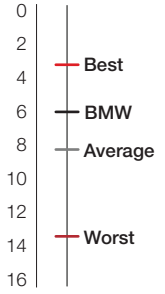
Sales by type



Advanced vehicles weighted rank



Autonomous & MaaS weighted rank



Appendix III: Methodology

Transition risks

The overall transition risks ranking is determined as follows:

We combine the weighted ranks of the three key areas using the following weightings: **Fleet emissions** 70%, **Manufacturing emissions & energy** 10%, and **Business resilience** 20%.

Fleet emissions

We assess company fleet emissions performance across four key markets: Europe, US, China and Japan.

We calculate the normalized sales exposure for each OEM to these four markets, and multiply it by the respective overall (weighted) rank for each market. This gives the overall fleet emissions weighted rank.

EU fleet emissions

The overall EU fleet emissions rank is determined as follows:

- We combine the weighted ranks for passenger vehicle (PV) and light commercial vehicle (LCV) performance relative to the ratio of PV sales to LCV sales. Where an OEM is exempt from LCV emissions regulation (total LCV registrations less than 1000), its weighted rank comes fully from its PV performance.

- We collate OEM's fleet average emissions, fleet average weight and registration data over the period 2010 – 2016 from the European Environment Agency (EEA) and crosscheck it with data from the International Council on Clean Transport (ICCT) and data reported to CDP.

Metric 1) Passenger vehicle performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2010 – 2016.[77] (The effects of super-credits are ignored to give a true reflection of reduction over the period). Companies that have reduced their fleet emissions quicker (i.e. a more negative CAGR) are ranked higher.

- We calculate each OEM's specific 2021 target by applying the formula used by the regulator (which is based on each OEM's fleet average mass in 2016) and account for the niche derogation targets for OEMs that have annual sales between 10,000 to 300,000 vehicles.

- We then calculate the CAGR (2016 – 2021) required to meet the 2021 target. Companies with a lower rate p.a. required to meet their target (i.e. a more positive CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2010 – 2016) and 70% weight to CAGR (2016 - 2021).

Metric 2) Light commercial vehicle performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2012 – 2016.

- We calculate each OEM's specific 2020 target using the formula used by the regulator and account for the niche derogation targets for OEMs that have annual sales between 1,000 to 22,000 vehicles.

- We then calculate the CAGR (2016 – 2020) required to meet the 2020 target.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2012 – 2016) and 70% weight to CAGR (2016 - 2020).

We recognize that each brand may form a pool with other brands to share a target (calculated on the basis of the fleet of the pool) and we note that Peugeot, Citroen and Opel are currently separate pools. To account for PSA Group's acquisition of Opel in a fair manner we have ranked on CAGR (2010 – 2016) for Peugeot and Citroen pools only and CAGR (2016 – 2021) for Peugeot, Citroen and Opel (sales weighted average of pools used to enable fair comparison with sample of companies).

Penalties

Estimated penalties are for illustrative purposes only and have not been used to rank companies. Forecasts are based on extrapolation of current trends (time series exponential smoothing with P10 and P90 lower and upper bound analysis) and assumptions surrounding expected sales of advanced vehicles for each company, accounting for super-credits (for passenger vehicles each vehicle less than 50g CO_2/km counted as 1.67 in 2021).

For 2020 (LCV) & 2021 (PV) the excess emissions premium for each vehicle registered is €95 for each g/km of exceedance.

We recognise that there are many measures companies can take to ensure that targets are met and that many of the OEMs state they are committed to complying with emissions regulations.

US fleet emissions

The overall US fleet emissions rank is determined as follows:

- We combine the weighted ranks for passenger vehicle (PV) and truck performance relative to the ratio of PV sales to truck sales.

77. Please note that here the CAGR is not calculated on only the first and last data point. The continuous compound growth rate (r) (exponential trend) is first calculated over all data points and then converted to an equivalent CAGR using exp(r) -1.

- We collate OEM's fleet average emissions, sales data and specific targets from the US EPA. We focus on actual fleet emissions reduction and ignore the impacts of compliance credits. (Fleet emissions are converted from gCO_2 / mile to gCO_2 / km to allow for comparison with other sections of the report. We note that 2016 data is preliminary and based on projected production data provided to EPA by OEMs.)

Metric 1) Passenger vehicle performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2011 – 2016. Companies that have reduced their fleet emissions quicker (i.e. a more negative CAGR) are ranked higher.
- We calculate the CAGR (2016 – 2021) required to meet each OEM's specific 2021 target. Companies with a lower rate p.a. required to meet their target (i.e. a more positive CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2011 – 2016) and 70% weight to CAGR (2016 - 2021).

Metric 2) Truck performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2011 – 2016.
- We calculate the CAGR (2016 – 2021) required to meet each OEM's specific 2021 target.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2011 – 2016) and 70% weight to CAGR (2016 - 2021).

China fleet emissions

The overall China fleet emissions rank is determined as follows:

- We combine the weighted ranks for Joint Venture (JV) and imported passenger vehicle performance relative to the ratio of JV sales to imported sales.
- We collate OEM's fleet average fuel consumption, sales data and specific targets from the Ministry of Industry and Information Technology (MIIT).

Metric 1) JV passenger vehicle performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2013 – 2016. Companies that have reduced their fleet fuel consumption quicker (i.e. a more negative CAGR) are ranked higher.
- We calculate the CAGR (2016 – 2020) required to meet each OEM's specific 2020 target. Companies with a lower rate p.a. required to meet their target (i.e. a more positive CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2013 – 2016) and 70% weight to CAGR (2016 - 2020).

Metric 2) Imported passenger vehicle performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2013 – 2016.
- We calculate the CAGR (2016 – 2020) required to meet each OEM's specific 2021 target.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2011 – 2016) and 70% weight to CAGR (2016 - 2021).

Japan fleet emissions

The overall Japan fleet emissions rank is determined as follows:

- We collate vehicle sales data per model from Bloomberg and Marklines.
- We collate OEMs' fuel economy performance and target values by model from the regulator, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). (Fuel economy figures km / L are converted to fuel consumption figures L / 100km to allow for comparison with other sections of the report.)
- MLIT's dataset provides details at sub-model level whereas the sales data we have is only available at a model level. Due to the lack of granularity in the sales data, we aggregate MLIT's sub-model level data by applying a straight average to get the model level data. We acknowledge that this approach could reduce the accuracy of our results.
- Although the regulator provides data on imported vehicles, we exclude them from the analysis due to the lack of sales data. All non-Japanese OEMs in our study export vehicles to Japan in some capacity but in very low volumes; thus, their exclusion in the Japanese fleet emissions analysis would not have a material impact on their overall ranking in the league table.

Metric 1) Passenger vehicle performance

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2012 – 2016. Companies that have reduced their fleet fuel consumption quicker (i.e. a more negative CAGR) are ranked higher.
- We calculate each OEM's specific 2020 target by assigning the 2020 fuel economy targets for each model weight category and producing a sales weighted average.

50. See Figure 48 in the 'Supplementary figures' section for example commodity demand scenario.

- We calculate the CAGR (2016 – 2020) required to meet each OEM's specific 2020 target. Companies with a lower rate p.a. required to meet their target (i.e. a more positive CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to CAGR (2012 – 2016) and 70% weight to CAGR (2016 - 2020).

Manufacturing emissions & energy

We combine the weighted ranks of the two metrics using the following weightings: metric 1) 50%, metric 2) 50%.

Metric 1) Emissions intensity performance

- We collate Scope 1+2 emissions intensity figures for each company from 2010 to 2016 using data reported to CDP and company sources. (Emissions are normalized by unit vehicle produced.)[78]

- We take the average of 2015 and 2016 as the company current emissions intensity. Companies with lower emissions intensity of production are ranked higher.

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2010 – 2016. Companies that have reduced their emissions intensity quicker (i.e. a more negative CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to the current emissions intensity and a 70% weight to the CAGR.

Metric 2) Energy intensity performance

- We collate energy intensity figures for each company from 2010 to 2016 using data reported to CDP and company sources. (Energy consumption is normalized by unit vehicle produced.)

- We take the average of 2015 and 2016 as the company current energy intensity. Companies with lower energy intensity of production are ranked higher.

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2010 – 2016. Companies that have reduced their energy intensity quicker (i.e. a more negative CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to the current energy intensity and a 70% weight to the CAGR.

Business resilience

We combine the weighted ranks of the four metrics using the following weightings: metric 1) 25%, metric 2) 25%, metric 3) 25%, metric 4) 25%.

Data is collated from company reports, investor presentations, Bloomberg, Marklines and data reported through the CDP questionnaire.

Metric 1) Exposure to emerging markets

- Companies are ranked based on the overall share of sales (excludes motorbikes) in emerging markets.

Metric 2) Diversification

- Companies are ranked based on the overall share of revenue coming from business areas that may suffer less disruptive change i.e. trucks & buses, motorbikes, parts and other areas such as machinery.

Metric 3) Share of sales from luxury vehicles

- Companies are ranked based on the overall share of luxury car sales (includes luxury sedans, limousines, super sports cars and large premium SUVs.)

Metric 4) EBIT margin

- Companies are ranked based on their Adjusted EBIT margin over the period 2015 – Q3 2017.

Limitations

- Fleet emissions analysis only covers performance in the EU, US, China and Japan to which the 16 companies have varying degrees of market exposure (as shown in Figure 3 on page 4). Due to data availability it was not possible to analyse other regions such as India, South Korea and Latin America. We encourage companies to disclose fleet emissions data relating to all markets of operation.

- Emerging markets vary in their stages of development and level of support for new vehicle technologies. A more in depth study could look at company exposure levels within each specific market vs. regional trends and company positioning against these trends.

Transition opportunities

The overall transition opportunities ranking is determined as follows:

We combine the weighted ranks of the four areas using the following weightings: **Advanced vehicles** 50%, **Autonomous driving & MaaS** 40%, **R&D** 5%, and **Renewable Energy** 5%

Advanced vehicles

The overall Advanced vehicles rank is determined as follows:

- We combine the weighted ranks of the four metrics using the following weightings: metric 1) 30%, metric 2) 25%, metric 3) 25%, metric 4) 20%.

78. For Honda and Suzuki we strip out the emissions associated with motorcycle production to enable fair comparison (78% of emissions attributed to passenger vehicle production for Honda and 90% of emissions for Suzuki, these figures were obtained through communication with each company).

Metric 1) Market share ratio

- We collate sales data from company reports, Bloomberg and Marklines.
- Global market shares for each company within each technology (FCVs, BEVs, PHEVs, HEVs) and total vehicle sales are calculated over the period 2010 – Q3 2017.
- OEM market shares for each technology are then divided by their market share of all vehicles to give market share ratios for each company.
- If the market share ratio is greater than 1.0 it indicates that a company's market share of that particular advanced vehicle technology is greater than their share of the total vehicle market and implies that the OEM is pursuing a low-carbon strategy.
- Companies are ranked on their total market share ratio over the period 2010 – Q3 2017.

The weighted rank for the metric is calculated by applying a 30% weight to FCV market share ratio, 30% weight to BEV market share ratio, 30% weight to PHEV market share ratio and 10% weight to HEV market share ratio.

Metric 2) Technical review

- We collate technical data for specific FCV, BEV and PHEV models from company reports, Marklines and the US DoE (fueleconomy.gov).
- Models are assessed on cost relative to vehicles in the same segment, electric range and efficiency (kWh / 100km, MPGe and km/ kg H2 for FCVs).
- We assign scores from 10 to 100 based on the percentile within each factor.
- For OEMs with more than one model available we take the highest score achieved by their respective models.

The technical weighted scores are calculated by applying a 40% weight to relative cost, 40% weight to electric range and 20% weight to efficiency. Companies are then ranked based off the technical score.

- For BEVs and PHEVs we also consider future models which are due for release. We combine the weighted ranks for current and future models with a weighting of 70% to currently available models and 30% to future models.
- For FCVs we consider a number of other factors to differentiate between companies including R&D collaborations on FCVs, models announced to be released, demonstration cars shown and domestic market attractiveness.

Metric 3) Advanced vehicle targets

- We collate information on OEM's advanced vehicle targets from company reports, investor presentations, press releases and CDP responses.
- Companies are ranked based on the ambition of the target, looking across the type of target (e.g. BEV only), volume of sales and target year.

Metric 4) Patents filed

- We source data from the Bakbasel study looking at the number of "world-class" patents filed by each company in the areas of electric vehicles (includes hybrids) and Li-ion batteries for vehicles. We supplement this study by looking at the total number of FCV patents filed by each company, sourcing data from Google patents.
- We normalize the number of patents filed by the number of automotive employees at each OEM in order to allow for fair comparison.
- For each technology, companies with a greater number of patents filed per employee are ranked higher.

The weighted rank for the metric is calculated by applying an equal weighting (33%) across EV patents, Li-ion patents and FCV patents.

Autonomous driving vehicles (ADVs) & MaaS

The overall ADV & MaaS rank is determined as follows:

- We combine the weighted ranks of the four metrics using the following weightings: metric 1) 20%, metric 2) 15%, metric 3) 30%, metric 4) 35%

Metric 1) Investments and acquisitions

- We source data from a study conducted by The Brookings Institute which collates data on all publicly disclosed OEM investments, acquisitions, mergers and partnerships relating to autonomous vehicles and ridesharing services over the period December 2014 – June 2017.
- The data is cross checked and supplemented with additional data from company reports, investor presentations and press releases to reflect investments up to year end 2017.
- Total OEM investments are normalised by total revenue over the period 2014 – 2017 and are ranked accordingly.

Metric 2) Partnerships and company services

The data sources for this metric are identical to metric 1.

- The metric accounts for the number of partnerships OEM's have with companies offering MaaS or developing ADV technologies. In addition, any internal OEM mobility services (i.e. services established independently by the OEM) are also considered.

- OEMs are ranked on the total number of partnerships and internal company services.

Metric 3) Automation targets

- We collate data on OEM automation targets from company reports, investor presentations, press releases and third-party sources.
- We rank companies based on the aggression of their automation targets. Here 'aggression' is characterised by the automation target level and the timeframe in which that target will be achieved; where a level 5 target at the earliest date is ranked the highest.

Metric 4) Patents filed and ADV testing

- We source data from the Bakbasel study[79] looking at the number of "world-class" patents filed by each company for ADV technologies.
- We normalize the number of patents filed by the number of automotive employees at each OEM in order to allow for fair comparison. Companies with a greater number of patents filed per employee are ranked higher.
- We source ADV road testing data from the state of California's Department of Motor Vehicles (DMV).
- Companies are ranked based on the number of disengagements (driver intervention) per 1000km driven during ADV road testing (fewer disengagements ranked higher).

The weighted rank for the metric is calculated by applying an equal weighting (50%) to patents filed and ADV testing.

Research and development

- We collate financial data and R&D expenses from company reports
- We rank companies on their R&D expense to sales ratio over the period 2014 – 2016.

Renewable energy

- We collate data on total energy consumption, split by fuel type, RE100 membership[80] and renewable targets from company reports and data reported to CDP (CC11 and CC3.1e).
- Companies are ranked positively based on the total percentage of energy consumption from renewable sources, level of ambition of renewable energy targets (CAGR implied by target where available) and whether they are a member of the RE100 initiative.

The weighted rank for the metric is calculated by applying a 50% weight to share from renewable energy, 40% weight to renewable energy targets and 10% weight to being a member of the RE100 initiative.

Limitations

- We are only able to assess OEM performance using information that is in the public domain. Given the commercially sensitive nature of some of the data, publicly available information may not always paint a full picture of an OEM's ambition or activities in the areas of advanced vehicles, automation and mobility services.
- OEM automation targets do not account for wider regulatory obstacles which could potentially delay their launch, creating a gap between technical and commercial viability.
- The number or quality of patents filed does not directly correlate with innovative output and is only one indication of developmental progress of the technologies considered in this analysis.
- Directly comparing the total number of strategic partnerships fails to account for differences in their scale and ambition.
- Comparing the performance of OEMs' ADVs by using disengagements per 1,000km does not account for differences in the ADV testing environment.

Climate governance and strategy

The overall governance and strategy rank and grade is determined as follows:

- We combine the weighted ranks of the seven-metrics using the following weightings: metric 1) 25%, metric 2) 25%, metric 3) 5%, metric 4) 5% metric 5) 15%, metric 6) 10%, metric 7) 10%, metric 8) 5%.
- This determines the overall weighted rank for climate governance and strategy.

Metric 1) Supplier engagement and life-cycle analysis (LCA)

Supplier engagement and life-cycle analysis is determined using a scorecard approach based on the following factors:

- The weighted rank is determined by compiling five supply-chain related metrics with the following weightings: supplier engagement score (30%), staff incentives (25%), upstream Scope 3 emissions accounting (15%) and LCA (20%).
- The supplier engagement score is determined by combining responses to CC14.4 which asks, "Do you engage with any of the elements of your value chain on GHG emissions and climate change strategies?" and CC14.4b which asks for the proportion of

79. Die innovativsten Unternehmen der Welt, Bakbasel
79. The RE100 initiative is a collaborative, global initiative of influential businesses committed to 100% renewable electricity: http://there100.org/

suppliers that companies' engage with, expressed as a percentage of total spend.

- Staff incentives uses CC2.1a to assess whether a company provides staff incentives for supplier engagement. This gives an indication as to the internal importance company's place on managing climate change in their supply chain.

- Scope 3 emissions accounting (CC14.1) provides a way for companies to quantify their upstream emissions. Companies are assessed on their disclosure of upstream "Purchased Goods and Services" emissions.

- Companies are assessed on the use of, and effectiveness of LCA in accounting for CO_2 emissions and further environmental factors in the production of automobiles. Analysis is taken from company reports and assesses the comprehensive of the assessment from "well-to-wheel", verification by certified external stakeholders and integration of the LCA into environmental management.

Metric 2) Emissions reduction targets
We assess companies on their emissions reduction targets based on an assessment of the following factors. (Where applicable aspects of the requirements set by the Science Based Targets Initiative (SBTi) have been incorporated into the analysis.)

- Companies Scope 1+2 targets are analysed separately. Scope 1+2 target scores are weighted 30% and Scope 3 target scores are weighted 60%. The remaining 10% is allocated to companies' commitment and engagement with the SBTi. Where a company has a single target encompassing Scopes 1,2 and 3, the target is assessed in the Scope 1+2 analysis and the Scope 3 analysis respectively.

Companies Scope 1+2 and Scope 3 scores (calculated independently but using the same criteria) are calculated based on the following criteria:

- Companies are scored higher for setting an absolute target over an intensity target. We consider absolute targets to be more ambitious than intensity targets (the SBTi states that intensity targets are only eligible when they lead to absolute emissions reductions). Where a company has set an absolute and intensity target, we analyse the absolute target. Where companies set more than one absolute or intensity target, the best target is used for analysis.

- Percentage of emissions covered: The SBTi states that companies may only exclude up to 5% of Scope 1+2 emissions in their inventory. Companies are scored based on the % of emissions covered by the target.

- Target length and base year: The SBTi states that companies must demonstrate that the target runs at least 5 years at initiation and encourage the setting of long-term emissions targets. Therefore, longer term targets are scored higher. The SBTi also recommends choosing the most recent year for which data are available for the base year and so companies with base years closer to 2017 are scored higher.

- Finally, companies are ranked on the CAGR implied by the emissions target from the base year until the target end date, with greater reductions favoured.

Metric 3) Emissions data verification:
We use the following approach to score companies according to their Scope 1,2 +3 emissions data transparency:

- The start point in the analysis is the proportion of emissions verified by a third party. We score this out of 10. If 100% are verified, this achieves 10 points. Then, points are awarded according to the proportion verified, i.e. a company with 86% of emissions verification is awarded 8.6 points.

- We then adjust the score (max 10) according to the uncertainty of the Scope verified. If the uncertainty is 5%, we deduct 0.5 points, if the uncertainty is 2%, we deduct 0.2 points, and so on.

- We multiply the remaining score according to the level of assurance as follows: high assurance = 100%; reasonable = 90%; moderate = 80%; limited = 70%; don't know yet = 50%; none = 0%.

- We then multiply the remaining score (still max 10) according to the status of the verification: complete = 100%; underway = 75%; none = 0%.

- We rank companies according to the final score (out of 30, 10 for each Scope of emissions), with higher scores ranking higher.

Metric 4) Climate-related remuneration:
- We assessed companies based on publicly available remuneration reports and responses to the CDP climate change questionnaire CC1.2 and CC1.2a.

- The focus is on senior executive remuneration (for short-term and long-term variable incentive programs) as well as company-wide (sub-executive) remuneration practices (at a monetary level only excluding competitions and awards).

- At the senior executive level, we developed a scorecard considering the quality of disclosure surrounding metric targets, historical performance against targets, climate-risk specificity of targets and overall proportion of variable incentives tied to climate performance.

- At a company-wide level we considered the overall quality of disclosure and practices.

- The weighted rank for this metric is calculated by applying a 40% rank to executive short-term remuneration, a 40% rank to executive long-term remuneration and a 20% rank to company-wide remuneration initiatives.

Metric 5) Board level climate responsibility and expertise:

- We assessed companies based on publicly available company reports and responses to the CDP climate change questionnaire (sections CC1.1 & CC2.2). The focus is on the level of climate expertise amongst board members, the quality of climate-related committees (at both board and executive levels) and the quality of the company's climate-risk management system.

- We developed a scorecard based on the level of climate expertise amongst board members. A 'climate experienced individual' was considered to be someone with direct experience of climate-related issues within business, policy or academia. We ranked companies on the percentage of their board members that were considered to be 'climate experienced individuals'.

- A scorecard was developed to assess the quality of climate-related committees at both board (60% weighting) and executive (40% weighting) levels. Companies that had separate climate-related committees at both board and executive levels received scores for both levels, as it demonstrates a stronger governance commitment to climate related risks and opportunities. Assessment of the quality of committees considered disclosure quality (of members, responsibilities and depth of climate-risk focus) as well as proportion of independent members (for board level committees).

- A scorecard was also developed to assess the quality of companies' climate-risk management systems. Assessment considered frequency of reporting to board, extent of geographical areas considered, extent of climate-risk time horizon considered, quality of disclosure and degree of integration of the system throughout the company.

- The weighted rank for this metric is calculated by applying a 20% rank to the number of climate-experienced directors on the board, a 40% rank to the quality of climate-related committees and a 40% rank to the quality of the company's climate-risk management system.

Metric 6) Use of an internal carbon price:

- We collect data on the use of internal carbon prices from companies' responses to question CC2.2c-d from the 2017 CDP climate change questionnaire.

- We rank companies according to whether they use an internal carbon price, whether they assess multiple scenarios, whether they disclose the price level(s) used and how high it is - with higher prices favored.

Metric 7) Water withdrawal intensity and management

We collate water withdrawal intensity figures for each company from 2010 to 2016 using data reported to CDP and company sources. (Water withdrawal is normalized by unit vehicle produced.)

- We take the average of 2015 and 2016 as the company current water withdrawal intensity. Companies with lower water intensity of production are ranked higher.

- We calculate the compound annual growth rate (CAGR) across all data points over the period 2010 – 2016. Companies that have reduced their water intensity quicker (i.e. a more negative CAGR) are ranked higher.

The weighted rank for the metric is calculated by applying a 30% weight to the current water intensity and a 70% weight to the CAGR.

Metric 8) CDP Score:

- The 2017 CDP Score (previously also known as CDP Performance Band) provides an aggregate measure of quality of climate-related disclosure and management systems addressing climate risks. CDP is committed to transparency and as such provides the full scoring methodology for every program online. In the next CDP reporting cycle (2018) CDP is moving to sector specific questionnaires which will align with the TCFD recommendations.

Limitations

- The breakdown of both the short-term and long-term remuneration schemes (at the executive level) was often not disclosed very clearly or in some cases was not disclosed at all. For instance, for many sustainability metrics it remained unclear to what degree climate performance influenced potential payments. For this reason, we considered climate-risk specificity in ranking metrics as well as the quality of disclosure surrounding targets, historical performance and proportion of total variable incentives. A similar approach was taken to assessing company-wide climate related remuneration initiatives (at a monetary level only).

- Judgement of professional climate experience was based on publicly available biographies and board of directors' profiles. These searches may have failed to identify some relevant director backgrounds.

Notes:

Notes:

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