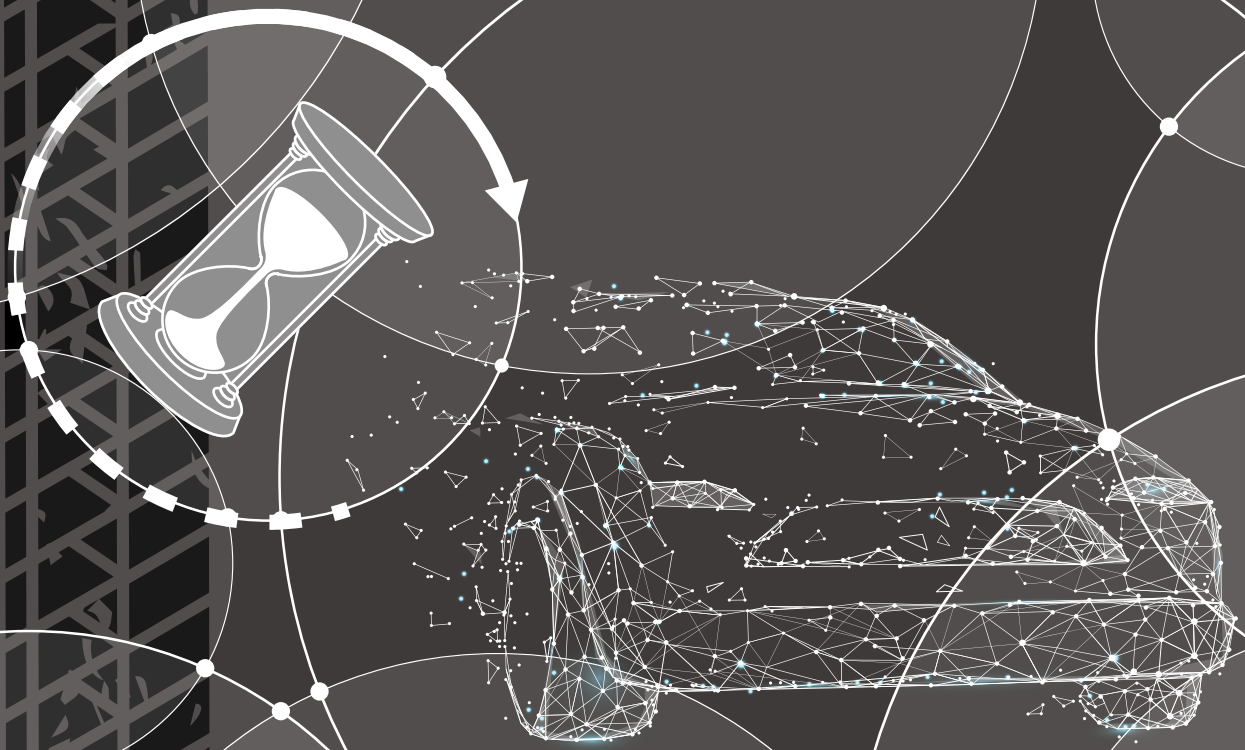
Countdown to Zero

Comparison of major automakers' carbon emission levels and compliance in China, the EU and the USA



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Executive summary

The transport sectors account for about 16% of global CO_2 emissions[1].The world's largest automakers, which sell millions of diesel or petrol cars each year, have an urgent responsibility to control their CO_2 emissions. Currently automakers are rushing to roll out their carbon-neutral plan. It is time to reexamine what they have done and tighten up their responsibilities in this critical period in the fight against climate change.

This report selected four world's best-selling carmakers Volkswagen, Toyota, Hyundai-Kia and Honda, compared their CO_2 emission performance from passenger cars in China, USA and the EU and analyzed the causes and impacts. Besides, the report also reviewed the progress on governmental CO_2 regulations for passenger vehicles among China, the EU and USA and explored the implications of those regulations on automakers' CO_2 performance.

The report demonstrates how the carmakers have repeatedly failed CO_2 standards for passenger cars in the key markets especially in less regulated regions. It is clear that carmakers' CO_2 performance is not progressive enough to keep pace with the increasingly stringent CO_2 emission standards in the markets. Critically, carmakers' average emissions from passenger vehicles in the less regulated regions are significantly higher than they are in the stricter ones.

As the report shows, the rapid growth of global SUV sales is a culprit of the carmakers' struggle to catch up with the emission standards in each core market. Besides, lack of strict CO_2 emission regulations and economic fines for the non-compliance slackened carmakers' CO_2 emission reductions. Finally, manufacturers' uneven adoption of fuel-efficient technology also makes average CO_2 emissions higher in less regulated markets. Yet elsewhere, the EU's progressive regulation showed an inspirational example: with the regulator's tightening CO_2 standards for passenger cars and effective enforcement, automakers were able to dramatically lower their CO_2 emissions.

The climate crisis is accelerating, and the carmakers have to act immediately to respond to it. Greenpeace urges carmakers to adopt the most advanced technologies to comply with the carbon emission standards in each market, reduce the CO_2 emissions in less regulated regions and halt the upward trend in SUVs sales.We urge policymakers to tighten emission standards and impose higher penalties for non-compliance, and improve the public transportation infrastructure.

Key findings

1. The EU enforces the most aggressive CO_2 emission standards for passenger cars and the strictest economic fines for carmakers that fail to meet the standards.

2. According to available data, in China, the four carmakers have once failed corporate average fuel consumption standards for passenger cars at least two times from 2016 to 2020. In the EU, none of the carmakers failed carbon emission standards from 2016 to 2019. In addition, all carmakers had much higher average CO_2 emissions from new passenger cars in China than in the EU from 2017 to 2019. Among them, Toyota's average CO_2 emissions in the EU were notably much lower than those of China.

3. After the EU tightened CO_2 emission standards for passenger cars in 2020, Volkswagen failed to meet the standards, based on the estimation from International Council on Clean Transportation.

4. Among the four carmakers, Hyundai-Kia has most frequently failed to meet CO_2 standards in the key markets. From 2017 to 2019, they have never met CO_2 standards for cars in the USA, and have not met corporate average fuel consumption standards for passenger cars in China since 2018. Similarly, Volkswagen has never met the CO_2 standards in the USA from 2017 to 2019, and has not met China's standards since 2019. Toyota has not met China's standards from 2016 to 2020, especially its joint venture FAW Toyota (Sichuan), which failed five times consecutively in China.

5. Most of the carmakers' joint ventures met China's corporate average fuel consumption standards for passenger cars in 2016, but failed to meet the standards in 2020. This means that the manufacturers' progress on fuel economy has not kept pace with the increasingly stringent fuel consumption standards in China.

6. Hyundai has not kept pace with USA's upgrading standards from 2017 to 2019. Volkswagen on average has the largest gap to the USA's standards among carmakers.

7. In terms of carbon emission reduction from 2017 to 2019, Volkswagen's and Honda's joint ventures have made the least improvement in China and Hyundai has made the least improvement in the USA.

8. Tightening regulations has significant impacts on carmakers' carbon emission reduction. EU's newly progressive regulation pressured carmakers to make dramatic emission reductions from 2019 to 2020.

10. Rapid growth of the SUV market contributes to carmakers' limited reductions in CO_2 emissions and failure to meet CO_2 standards.

11. Loose regulation, manufacturer's uneven deployment of fuel-efficient technologies and the manufacturers' appeal to the market for heavier and large-size cars contribute to higher average CO_2 emissions in China, especially compared to the EU.

01

Comparison of CO_2 regulations for passenger vehicles from 2015 to 2030

This section provides an overview of CO_2 emission standards and regulations for passenger vehicles (PVs) in the EU, China and USA from 2015 to 2030. This section mainly compares CO_2 regulations for PVs among these three regions in terms of CO_2 emission standards, test cycles and economic penalties.

1.1 EU enforces the strictest CO_2 standards for passenger cars

Table 1.1 indicates the CO_2 regulations for new passenger cars (2015-2025) among the EU, China and USA.

Table1.1 Comparison of CO_2 standards for new passenger cars (g CO_2/km) under NEDC and required reduction rates [2]

	2015 Target	2020 Target	2025 Target	2015-2020 Rate	2020-2025 Rate
China	167	120	95	-28%	-21%
USA	161	128	/	-21%	/
EU	130	95	81	-27%	-15%

The EU has set the strictest CO_2 emission standards for PVs. In December 2009, the European Parliament adopted mandatory emission performance standards for new passenger cars, which set an average fleet-wide CO_2 emission standard of 130 g/km for 2015.[3] The 130 g/km standard had to be met by each vehicle manufacturer by 2015 and into 2019. Since 2014, the European Parliament and the Council of the EU has set a standard value of 95 g/km of CO_2 for 2020 under the New European Driving Cycle (NEDC). This includes a one-year phase-in period requiring 95% of new car sales to comply with the standard, and 100% of car sales to comply by the end of 2020 (Regulation (EU) No 333/2014).[4] In 2018, the European Commission, the European Parliament and the European Council agreed on CO_2 emission standards for 2025 and 2030, which aim to reduce the average CO_2 emissions from new cars by 15% by 2025 and 37.5% by 2030 relative to a 2021 baseline.[5] These standards correspond to a value of 81 g/km in 2025 and 59 g/km in 2030 under the NEDC. At the time of writing, the EU commission planned to tighten the CO_2 emission standards further, and proposed to reduce the average CO_2 emissions from new cars by 55%, instead of the previous 37.5%, by 2030 as compared to a 2021 baseline.[6]

China set an average fleet standard of approximately 7 L/100 km for new PVs in 2015, corresponding to a CO_2 emission standard of 167 g/km (under NEDC) when it released the Phase III fuel consumption standards (GB 27999-2011) for PVs in 2011, which began enforcement in 2012. After that, Phase IV fuel consumption standards (GB19578-2014, GB 27999-2014) for PVs were issued in 2014 and enforced in 2016.[7,8] These set an average fleet standard of about 5.0 L/100 km for new PVs in 2020, which corresponds to a standard value of 120 g/km CO_2 emission under NEDC. Phase V fuel consumption standards for passenger vehicles (GB 19578-2021, GB 27999-2019) have been issued and effective since 2021.[9,10] These most recent standards set an average fleet standard of 4.0 L/100 km for all new passenger vehicles by 2025, corresponding to a standard value of 95 g/km CO_2 emission under NEDC. These standards are attached to China's aim to reduce the average CO_2 emission from new cars by 21% in 2025 (as compared to 2020 standards).

In the USA, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) issued rules for light-duty vehicle GHG emission standards and corporate average fuel economy standards.[11,12] Under these rules, the CO_2 standards for new passenger cars were 161g/km (under NEDC) in 2015 and 128g/km (under NEDC) in 2020. After that, Trump administration drastically scaled back the previous administration's 2025 target when it rolled out the 2020 safe rule. But at the time of writing, the Environmental Protection Agency (EPA) proposed new greenhouse gas emission standards for new passenger cars and light-duty trucks. The new proposal set the 2025 of target by 149 g/mi.

1.2 Test cycle

In addition to the CO_2 standards, the test cycles that are used to test and report CO_2 emission levels among the three regions also differ.

The EU has adjusted their test cycles from NEDC to the new Worldwide Harmonized Light Vehicles Test Procedure (WLTP) from 2020 onward.[13,14] China also applied NEDC to test and report CO_2 emission up until 2020, and transited the standards from NEDC to WLTP from 2021.[15] A stricter and more localized test cycle will be applied from 2025.[16] The USA applied the Federal Test Procedure 75 (FTP-75) weighted with the highway cycle for emission certification and fuel economy testing (hereafter "USA combined").[17]

Which test cycle is more demanding? There is no straightforward answer because the stringency of test cycles depends on different vehicles. Generally, for gasoline vehicles, WLTP is the most demanding procedure, with emissions 15% higher than the USA combined cycle, and 13% higher than the NEDC[18]. NEDC is more demanding than the USA combined cycle. If the vehicles are diesel cars, the stringency of test cycles changes. For diesel cars, NEDC is about 10% more demanding than the US combined cycles for high-efficiency cars, but less demanding for low-efficiency cars[19]. WLTP matches the NEDC for low efficiency vehicles, and matches the USA combined cycles for high efficiency cars[20]. The strictness of the test cycles for gasoline vehicles can be seen in Table 1.2. For example, compared to NEDC, WLTP is 13% more demanding for gasoline vehicles.

Table 1.2 Comparison of three test cycles for gasoline vehicles [21]

Region: Regime	Compared to WLTP	Strictness
EU: NEDC & WLTP	WLTP/NEDC=1.13	+++
China: NEDC & WLTP	WLTP/NEDC=1.13	+++
USA: USA combined	WLTP/US combined=1.15	++

1.3 EU enforces strictest economic penalties while China still lacks economic penalties

The EU and USA impose economic fines on carmakers that fail CO_2 standards for passenger cars. China has not imposed economic penalties for violators. The EU has imposed the strictest economic fines. For example, the penalty for manufacturers that fail to meet their standards in the EU is that the manufacturer pays an excess emissions premium of € 95 per g/km of target exceedance for each of its vehicles newly registered in that year.[22] For the USA, manufacturers whose fleets fail to meet standards (after the consideration of credits) are liable for a civil penalty of $5.50 per each tenth of a mpg under the standard value.[23] For China, there are no economic penalties for missing the standards. According to China's dual credit policy[24], manufacturers that fail to comply with the requirements of the policy will be punished through non-economic measures including notification as a trust-breaking enterprise, order for adjusting production plans, withdrawing certification for substandard models, etc.[25]

1.4 Conclusion

Overall, we can see the differences in CO_2 standards for passenger cars among the three regions. The strictest standards are in the EU. While the EU have issued or agreed upon their CO_2 standards for 2030, China has only released their fuel consumption standards up to 2025. The USA has released their emission standards up to 2026. More stringent standards can be seen in the U.S for 2023 and onwards due to the newly proposed emission standards by the Biden administration.

02

CO_2 performance of new passenger cars in the three core markets: comparing carmakers

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The following sections will mainly compare manufacturers' CO_2 performance in the EU, USA and China.

2.1 Hyundai-Kia has most frequently failed to meet the CO_2 standards

Because foreign manufacturers in China are required to partner with domestic corporations in order to produce vehicles, the data about foreign manufactures' corporate average fuel consumption published by the Ministry of Industry and Information Technology are based on joint ventures. To assess if the carmakers meet China's corporate average fuel consumption standards for passenger cars, in this report, a carmaker meets corporate average fuel consumption standards for passenger vehicles only if its all joint ventures meet the standards in the same year. According to the data from the Ministry of Industry and Information Technology, EPA and EEA the four carmakers' compliance with CO_2 standards for passenger cars in China, the EU and USA are presented as following:

a. China

Table 2.1 The four carmakers' compliance with China's corporate average fuel consumption standards for passenger cars from 2016 to 2020 [26]

Manufactures	Joint ventures	2016	2017	2018	2019	2020	Total number of failures to meet standards
VW	Overall	Yes	Yes	Yes	No	No	2
	SAIC VW	Yes	Yes	Yes	No	No	
	FAW VW	Yes	Yes	Yes	No	No	
Toyota	Overall	No	No	No	No	No	5
	FAW Toyota(Sichuan)	No	No	No	No	No	
	GAC Toyota	Yes	Yes	Yes	Yes	No	
	FAW Toyota(Tianjin)	Yes	Yes	Yes	Yes	Yes	
Honda	Overall	Yes	Yes	No	No	No	3
	Dongfeng Honda	Yes	Yes	No	No	No	
	GAC Honda	Yes	Yes	No	No	No	
Hyundai-Kia	Overall	Yes	Yes	No	No	No	3
	Beijing Hyundai	Yes	Yes	No	No	No	
	Dongfeng Yueda Kia	Yes	Yes	No	No	No	

b. EU

Table 2.2 The four carmakers' compliance with EU's carbon emission standards for passenger cars from 2016 to 2019 [27]

Manufactures/ Car pool		2016	2017	2018	2019	Total number of failures to meet standards
VW Group		Yes	Yes	Yes	Yes	0
Hyundai-Kia	Kia	Yes	Yes	Yes	Yes	0
	Hyundai	Yes	Yes	Yes	Yes	0
Toyota		Yes	Yes	Yes	Yes	0
Honda		Yes	Yes	Yes	Yes	0

c. USA

Table 2.3 The four carmakers' compliance with USA's CO_2 standards for car from 2017 to 2019 [28]

Manufactures		2017	2018	2019	Total number of failures to meet standards
Volkswagen		No	No	No	3
Hyundai-Kia	Kia	No	No	No	3
	Hyundai	No	No	No	
Toyota		Yes	Yes	Yes	0
Honda		Yes	Yes	Yes	0

Figure 2.1 shows the four automakers' failure to meet CO_2 standards for passenger cars in China, the USA and the EU. Among the four carmakers, Hyundai-Kia has most frequently failed to meet CO_2 standards in the key markets. From 2017 to 2019, they never met CO_2 standards in the USA, and did not meet China's corporate average fuel consumption standards from 2018 to 2020. VW also never met the standards in the USA from 2017 to 2019, and has not met China's standards since 2019. Toyota and Honda, meanwhile, performed differently in China as compared to other regions. Toyota has not met China's standards from 2016 to 2020, especially its joint venture FAW Toyota (Sichuan), which failed five times consecutively in China. But, after receiving heavy fines for the violation of the Clean Air Act from 2005 to 2015[29], Toyota has met standards in the USA from 2017 to 2019, and has met standards in the EU from 2016 to 2019. Also, Honda has not met China's standards since 2017, but has met the standards in the EU and USA from 2017 to 2019.

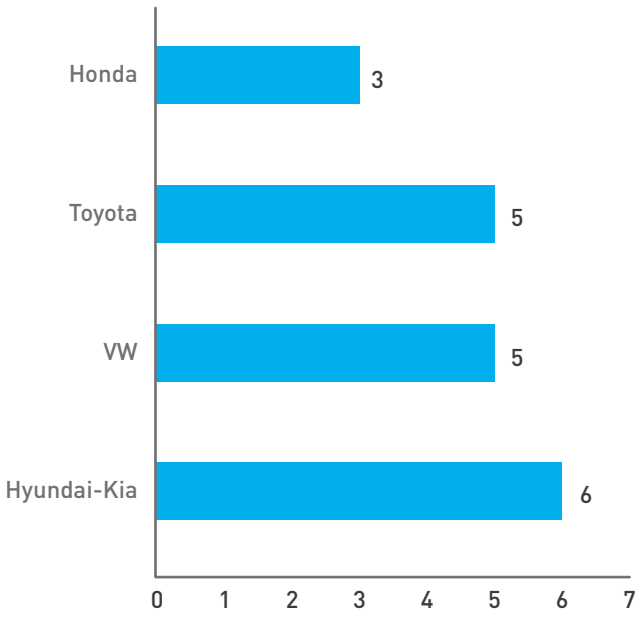

Figure 2.1 Total number of carmakers' violations of CO2 regulations for passenger cars in China (2016-2020), the EU (2016-2019) and USA (2017-2019)

2.2 The latest estimation shows Volkswagen lagged behind EU's carbon emission standards

Since the EU has not officially finalized the data about manufacturer's CO_2 emissions in 2020, the final results of the manufactures' compliance with the CO_2 emission standards for passenger cars are not yet available. But based on the estimation from ICCT, VW is the only one that missed the emission targets in 2020 among the manufacturer groups.

The following table is the assessment of the manufacturers' compliance with the EU's standards in 2020 from ICCT's report. Most manufacturers met the EU CO_2 standards in 2020 except for Volkswagen, which missed the target by 1%. Hyundai-Kia's emission performance was well below the standard.

Table 2.4 Estimated gap between of manufacturers' average CO2 emissions from new passenger cars and EU's CO_2 standards for 2020[30]

Manufacturer pool	CO2 performance(g/km)	Target(g/km)	Gap(g/km)
VW	100	99	1
Hyundai	93	96	-3
Toyota	94	96	-2
Honda	/	/	/
Kia	93	96	-3

Since the carmakers frequently failed to meet the standards in China and the USA, it is worth examining if they have made efforts to catch up with the standards in both markets.

In China, most of the carmakers' joint ventures met China's corporate average fuel consumption standards for passenger cars in 2016, but failed to meet the standards in 2020 (see Figure 2.2). This means that the manufacturers' progress on fuel economy has not kept pace with the increasingly stringent fuel consumption standards in China. Among them VW and Hyundai-Kia are the worst performers. For example, FAW VW were 10.4 g/km ahead of standards in 2016, and 13.5 g/km in excess by 2020. Similarly, Hyundai-Kia's joint venture Dongfeng Yueda Kia also performed poorly. Dongfeng Yueda Kia hit the standard in 2016, but ended up behind the standard by 20.3 g/km.

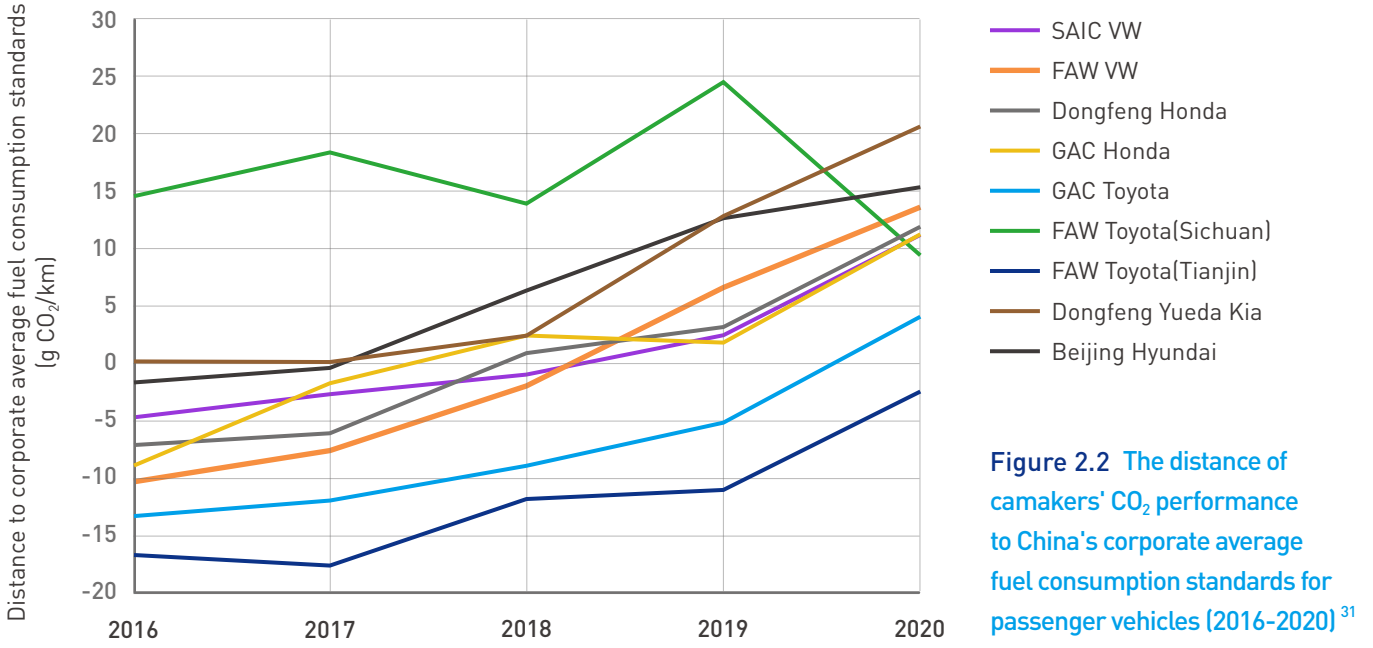

Figure 2.2 The distance of camakers' CO_2 performance to China's corporate average fuel consumption standards for passenger vehicles (2016-2020) [31]

In the USA, VW and Hyundai-Kia consecutively failed to meet the CO_2 standards for car from 2017 to 2019. During this period VW's average gap to the CO_2 standards is around 14 g/km, which is the highest among the carmakers. Hyundai's excess emissions have grown (see Figure 2.3), which means that Hyundai's progress on fuel economy has not kept pace with USA's upgrading standards. On the other hand, Honda and Toyota are far ahead of standards in the USA. In the USA, Honda and Toyota have on average been 14 g/km and 6 g/km ahead of standards respectively, during this period.

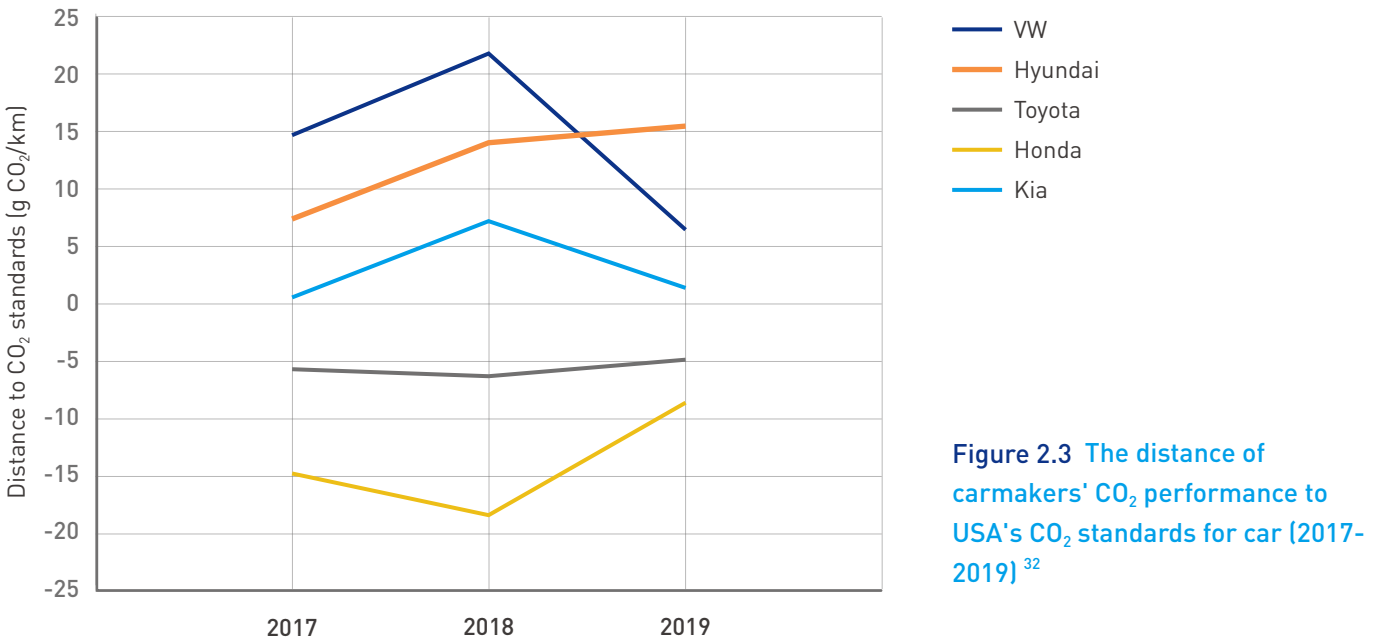

Figure 2.3 The distance of carmakers' CO_2 performance to USA's CO_2 standards for car (2017-2019) [32]

03

The four carmakers' carbon emission improvement and difference across regions

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3.1 Hyundai's average carbon emissions are the highest in the USA

We calculated the carmakers' average annual CO_2 emissions from new passenger cars in China, the USA and the EU from 2017 to 2019 (see Figure 3.1-3.3). In the EU, Toyota's CO_2 performance were ahead of the carmakers with average CO_2 emissions around 107g/km from 2017 to 2019. Honda's average annual CO_2 performance lagged the farthest at 126g/km.

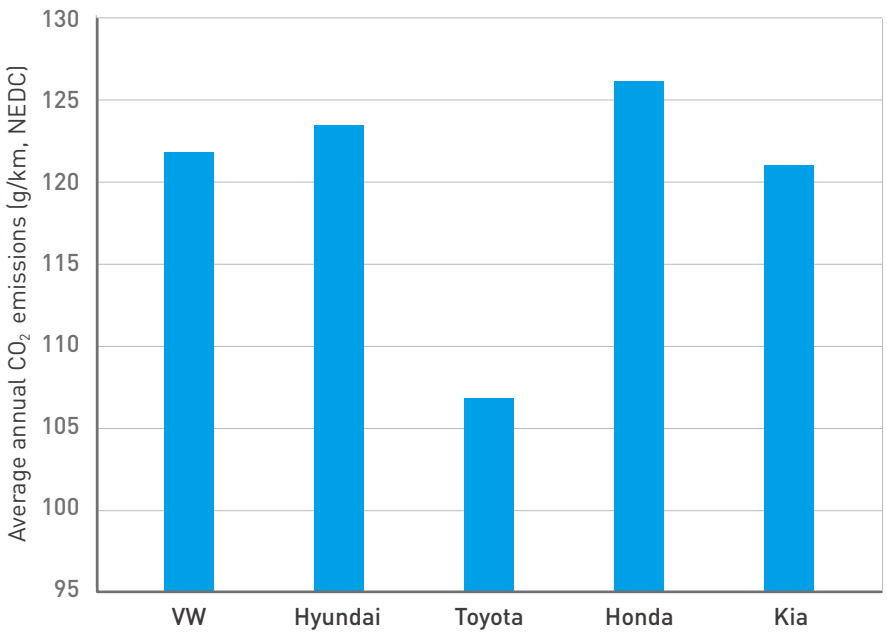


Figure 3.1 Average annual CO_2 emissions of the manufacturers (car pool or manufacturers) in the EU (2017-2019) [33]

In China, all manufacturers except Toyota's two joint ventures -FAW Toyota (Sichuan) and FAW Toyota (Tianjin) had average yearly CO_2 emissions around 142g/km-148g/km from 2017 to 2019. Toyota Group's CO_2 performance is mixed. FAW Toyota(Sichuan) tops the list with an average CO_2 emission of 181 g/km from 2017 to 2019 but Toyota's another joint venture FAW Toyota(Tianjin)'s average CO_2 emission is the lowest among carmakers during the same period. Hyundai's joint venture Beijing Hyundai's average CO_2 emission is the second highest, at 148g/km per year.

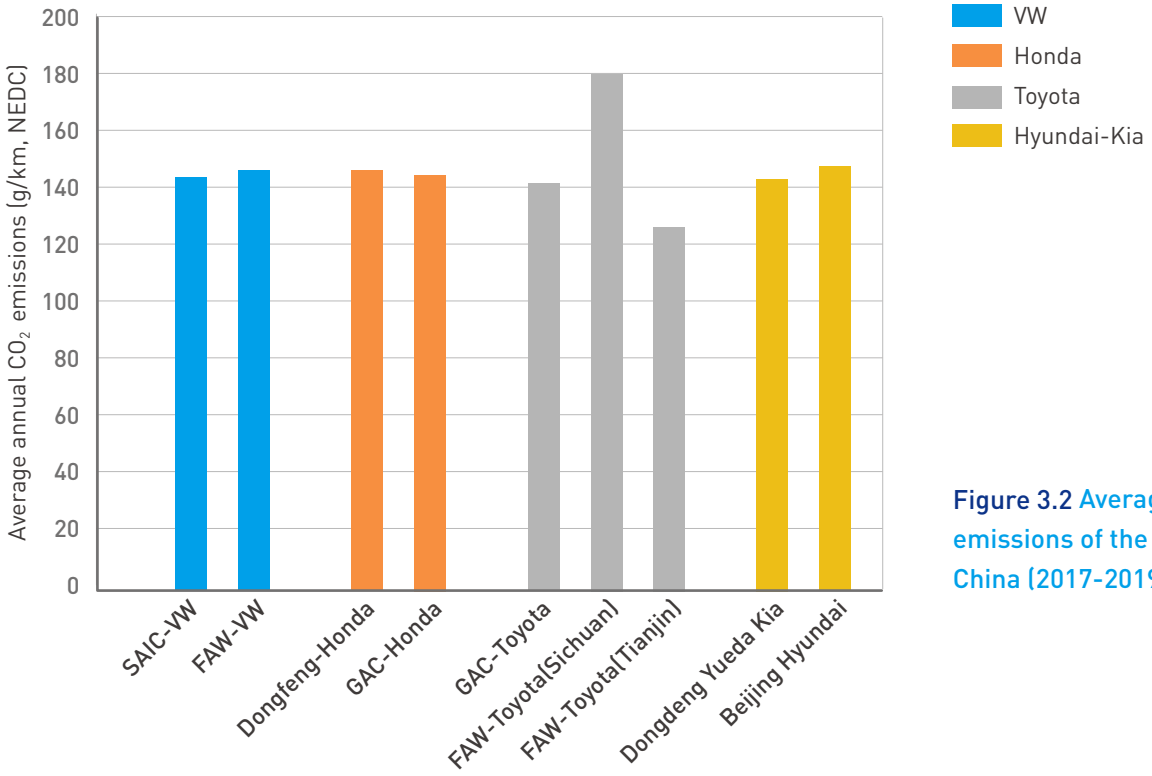
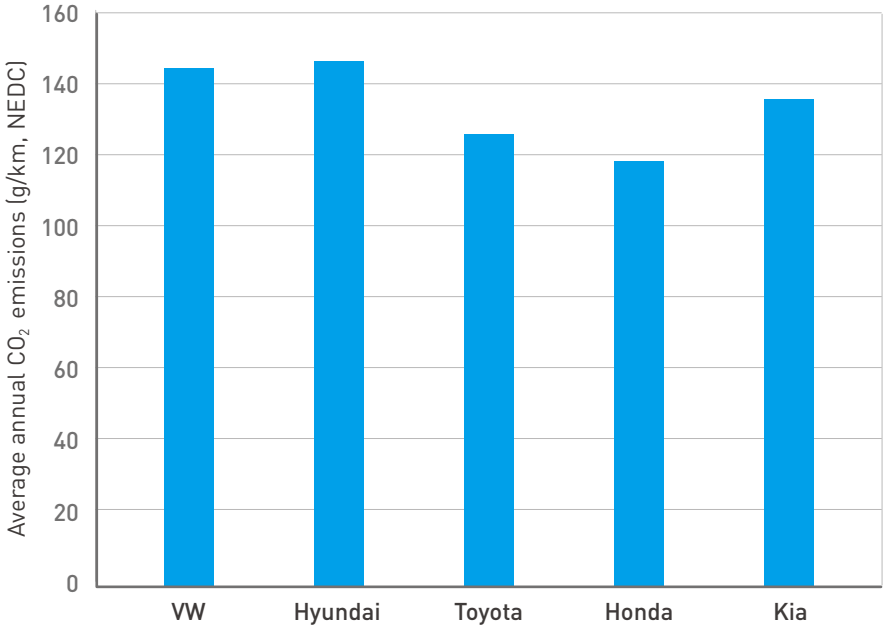


Figure 3.2 Average annual CO_2 emissions of the manufacturers in China (2017-2019) [34]



In the USA, Hyundai's average carbon emissions are highest among the carmakers from 2017 to 2019. Hyundai and VW reached the average annual emission of 147 g/km and 145 g/km, respectively. And Honda's average CO_2 emission is the lowest among the carmakers during the same period, reaching 119 g/km.

Figure 3.3 Average annual CO_2 emissions of the manufacturers in USA (2017-2019) [35]

3.2 VW's and Honda's joint ventures have made the least improvement in carbon emission reduction in China; Hyundai has made the least improvement in the USA

The EU implemented tight regulation in 2020 and carmakers' average CO_2 emissions from new passenger cars began to decrease significantly.[36] (see Figure 3.4.) Based on estimation, Hyundai's and Kia's average CO_2 emissions from new passenger cars have dropped by 25% and 24% respectively from 2019 to 2020. From 2016 to 2019, most manufacturers had barely reduced average CO_2 emissions from new passenger cars, and Toyota and VW both increased their average CO_2 emissions by 3% from 2016 to 2019. Hyundai and Kia only reduced their average CO_2 emissions by 1% and 2 %, respectively, during the same period.

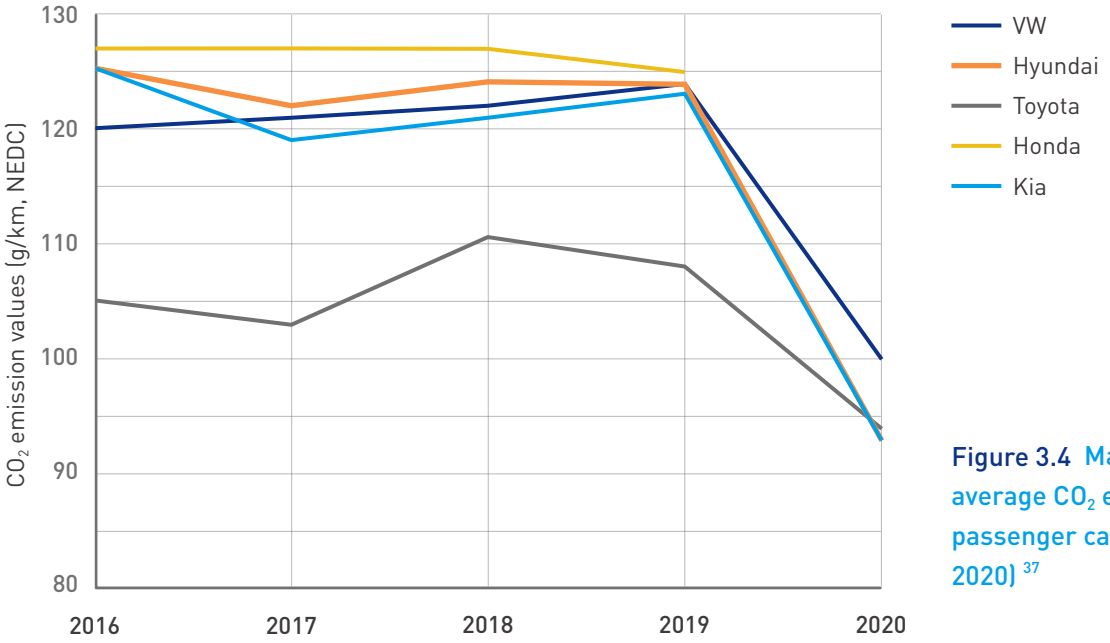


Figure 3.4 Manufacturers' average CO_2 emissions from new passenger cars in the EU (2016-2020) [37]

In China, a steadily decreasing trend can be seen for the carmakers from 2016 to 2020 (see Figure 3.5). In terms of manufacturer groups, VW's and Honda's joint ventures have made the least improvement and they have reduced CO_2 emissions from new passenger cars by around 11%, respectively[38] (on average annual reduction rate of 2%) from 2016 to 2020. The CO_2 emission reduction made by Toyota's joint ventures has been on average 18% (annual reduction rate of 3.6%) from 2016 to 2020 and led ahead among the carmakers, but improvements still lagged behind the progress of China's fuel consumption standards, which required an annual reduction rate of 4.7% from 2015 to 2020. In terms of joint ventures, Honda's joint venture GAC Honda and Volkswagen's joint venture FAW VW had the smallest improvement in emission reduction from 2016 to 2020, with 8.9% and 9.7%, respectively.

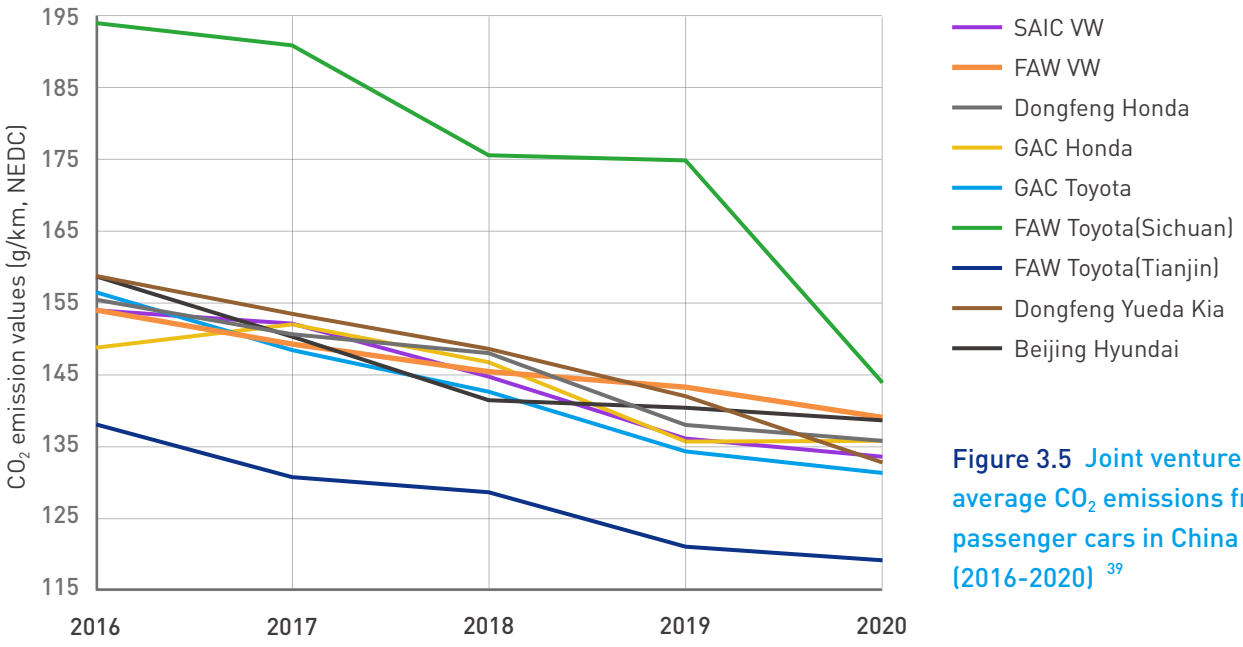


Figure 3.5 Joint ventures' average CO_2 emissions from new passenger cars in China from (2016-2020) [39]

In the USA, the manufacturers have made some improvements in carbon emission reduction from 2017 to 2019. The least improvement was made by Hyundai, whose average CO_2 emissions from new passenger cars only has decreased by 4% from 2017 to 2019 (with an average annual reduction rate of 1.3%).

This improvement lagged far behind USA's upgrading standards, which required an annual reduction rate of 3.5% CO_2 emissions for PVs from 2015 to 2020. VW and Kia cut average CO_2 emissions by 15% and 11% , respectively, from 2017 to 2019.

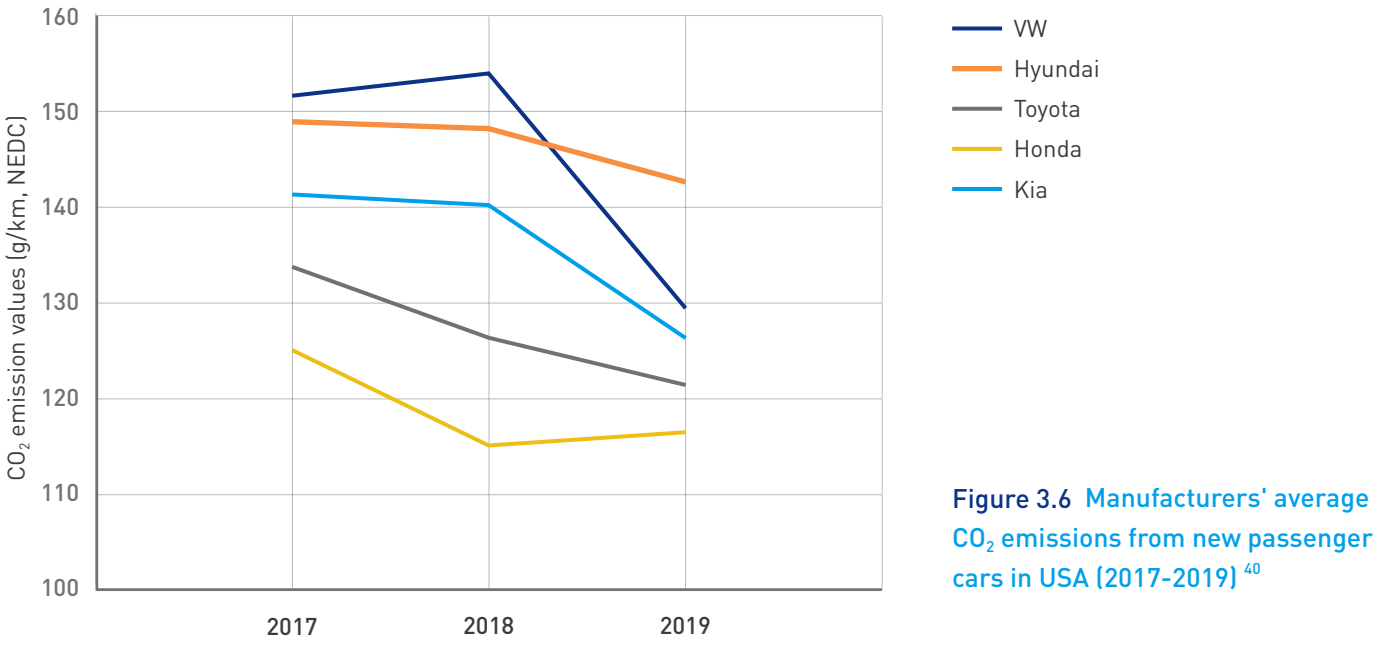


Figure 3.6 Manufacturers' average CO_2 emissions from new passenger cars in USA (2017-2019) [40]

3.3 All manufacturers had higher average carbon emissions in China than in the EU and USA from 2017 to 2019

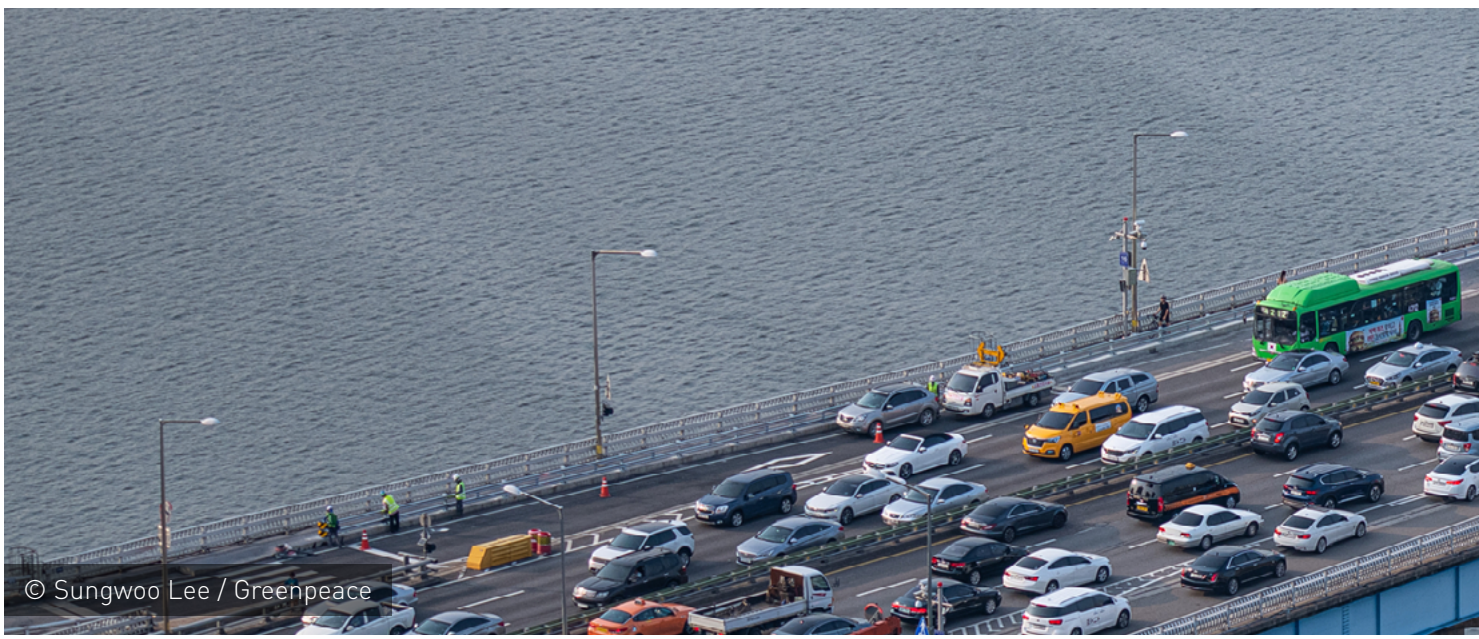
Due to the data availability, this section compares carmakers' average CO_2 emissions from new passenger cars among China, the EU and USA from 2017 to 2019 and examines automakers' efforts to reduce carbon emissions in less regulated regions.

Since China has not published the data on manufacturer group's average CO_2 emissions, to compare those carmakers' CO_2 performance, this section used average annual CO_2 emissions from the carmakers' biggest joint ventures (in terms of average production units in recent five years) from 2017 to 2019 to compare them with the carmakers' average CO_2 performance in the EU and USA during the same period. In figure 3.7, VW (China), Toyota (China), Honda (China), Hyundai (China) and Kia (China) refer to FAW VW, GAC Toyota, GAC Honda, Beijing Hyundai and Dongfeng Yueda Kia respectively[41].

All manufacturers had much higher average CO_2 emissions in China than in the EU from 2017 to 2019 as seen in Figure 3.7. On average, the average annual carbon emissions from Toyota's major joint venture GAC Toyota in China has been on average more than 30% higher than Toyota's emissions in the EU from 2017 to 2019. This is the widest gap among the carmakers. The average CO_2 emissions from VW's and Hyundai's major joint ventures FAW VW and Beijing Hyundai, respectively, were around 20% higher than the emissions from VW and Hyundai in the EU during the same period.

The average annual average CO_2 emissions from the carmakers' major joint ventures in China were higher than the carmakers in the USA from 2017 to 2019 (see Figure 3.7). Namely, the average annual carbon emissions from Honda's major joint venture GAC Honda in China has been on average more than 20% higher than Honda's emissions in USA from 2017 to 2019, and the average annual carbon emissions from Toyota's major joint venture GAC Toyota in China has been 11% higher than Toyota's emissions in USA during the same period.

All manufacturers except for Honda had higher average CO_2 emissions in the EU than in the USA from 2017 to 2019 (See Figure 3.7). VW's, Toyota's and Hyundai's average CO_2 emissions in USA were each 19% higher than theirs in the EU during the same period.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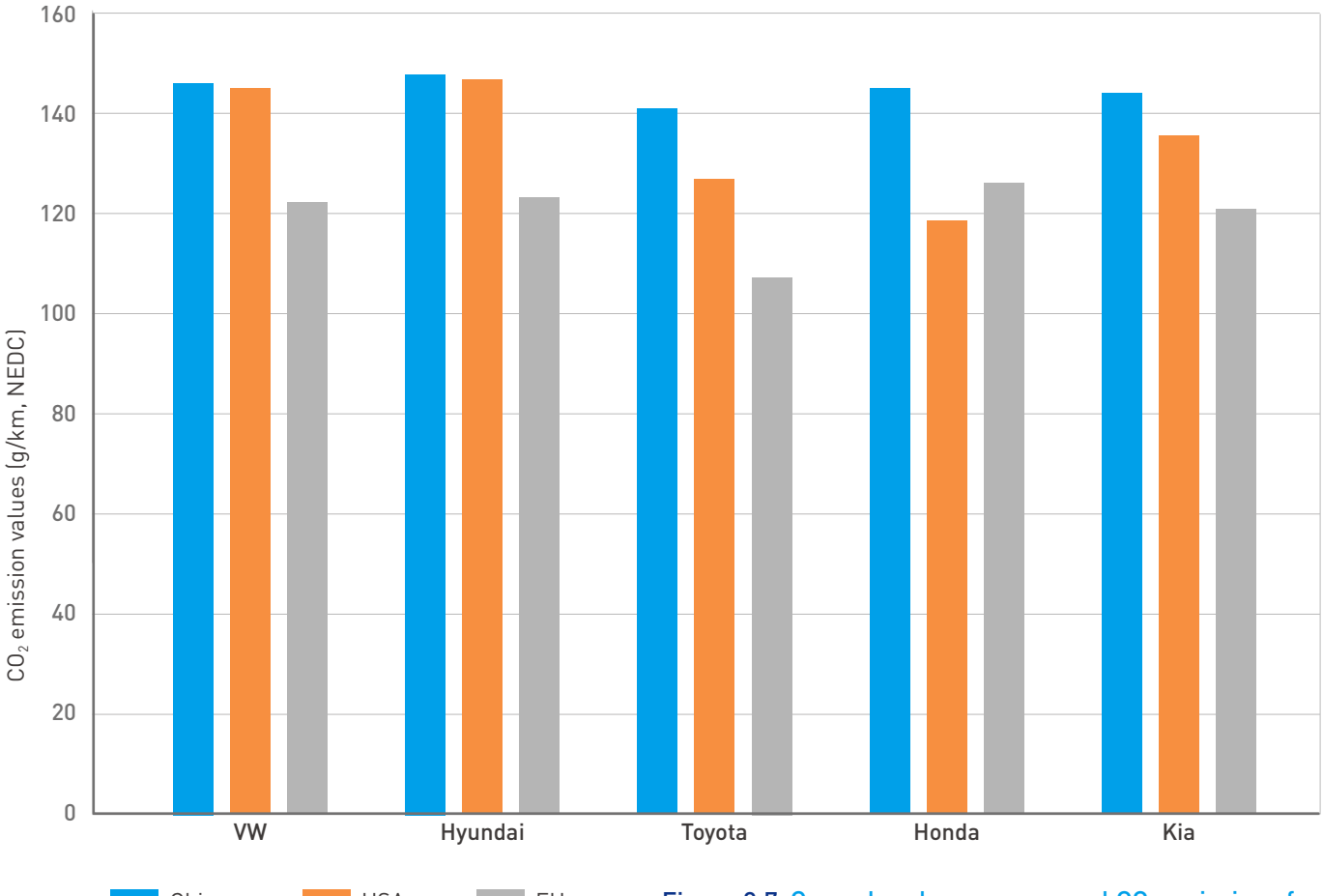

Figure 3.7 Carmakers' average annual CO_2 emissions from new passenger cars in China, the EU and USA from 2017 to 2019 [42]

04 Discussion

4.1 Tightening regulation has significant impacts on carmakers' carbon emission reduction

Carmakers' average carbon emissions from new passenger cars in the EU significantly decreased from 2019 to 2020 as the regulators tightened emission standards(See Figure 3.4). In addition to consumer preference, one possible explanation is in the strictness of carbon emission standards and regulation for passenger vehicles set by the government.

In the EU, the CO_2 target for passenger cars dropped significantly from 130g/km in 2019 to 95g/km in 2020. Meanwhile, the economic penalty for the carmakers that failed to meet the CO_2 emission standards is also strict. The manufacturers that exceed standards in the EU are obliged to pay an excess emissions premium of € 95 per g/km of target exceedance for each of its vehicles newly registered in that year.

From 2016 to 2019, the carmakers' average CO_2 emissions from new passenger cars in the EU were stable or even increased. But as the 2020 carbon emission standard is implemented, the carmakers' average CO_2 emissions dramatically decreased. For example, Kia's and Hyundai's average CO_2 emissions dropped by 24% and 25%, respectively, from 2019 to 2020. And VW and Toyota have also reduced emissions by 19% and 13%, respectively. Factors such as the Covid-19's impact on supply chain might affect carmakers' performance, but the EU's tight standards and harsher penalties can be argued as one of the key contributors to the carmakers' to improve the fuel efficiency.

According to the European Environment Agency's latest data, average CO_2 emissions of new passenger cars in the EU in 2020 are 12% lower than in 2019.[43] Carmaker's CO_2 performance in the EU makes the strong case for the point that with tight reglulation and effective enforcement, carmakers can sharply reduce their carbon footprint in a short period of time.

4.2 Rapid growth of SUV sales contribute to carmakers' poor performance

It has been seen that Hyundai-Kia, VW and Toyota have frequently failed to meet CO_2 standards in China and the USA. This might be related to the carmakers' rapid growth of SUV sales, which have been proven to cause higher carbon emissions.

The SUV's impact on carbon emissions cannot be ignored. Fuel consumption and vehicle weight are closely related. The heavier the car, the greater the need for the engine power, the more fuel is consumed, the higher the CO_2 emissions[44]. According to calculations from International Energy Agency, the global fleet of SUVs has seen its emissions growing to roughly 0.7 Gt CO_2 during the last decade. After the power sector, SUVs have been the second-largest contributor to the increase in global CO_2 emissions since 2010.[45]

The rapid increase in SUV sales is a global trend. The global market share of SUVs increased from 22.4% in 2014 to 36.4% in 2018.[46] Meanwhile, the market penetration of SUV in the world's three largest car markets (China, the EU and the U.S)-reached 42%, 34% and 45%, respectively in 2018.[47] The rapid growth of SUV sales by Volkswagen, Toyota and Hyundai-Kia follow this trend.

The following table shows global SUV sales from the four carmakers from 2016 to 2018. Volkswagen Group, Toyota and Hyundai-Kia maintained a rapid increase in their global sales of SUVs. Among them, the sales of Volkswagen group grew more rapidly than the other manufacturers. Volkswagen group's SUV sales increased from 1.46 million units in 2016 to 2.49 millions in 2018, with average annual growth rate of 24%[48]. In addition, Toyota and Hyundai-Kia also maintained average annual growth of 12.5% and 6% respectively. By 2018, Toyota, Hyundai-Kia and Volkswagen ranked second, third, and fourth in global SUV sales.[49]

Table 4.1 Global SUV sales by carmakers from 2016 to 2018(Units sold in million)[50]

	Units sold in 2016	Units sold in 2017	Units sold in 2018
Toyota	1.88	2.34	2.59
Volkswagen Group	1.46	1.96	2.49
Hyundai-Kia	2.12	2.01	2.50
Honda	1.76	1.96	1.92

4.3 Why the manufacturers' average CO_2 emissions are significantly higher in China?

The carmakers' average annual carbon emissions from new passenger cars in China were much higher on average than in the EU from 2017 to 2019 (see Figure 3.7). There are several factors to contribute to the disparity.

One contributing factor is stringency of the CO_2 regulations for passenger cars. In 2020, China's fuel consumption standards were 25 g CO_2/km less demanding than the EU standards. In spite of that, the pace of upgrading the standards in China is not much faster than the EU from 2015 to 2020. For example, the CO_2 emission reduction rate required by China's fuel consumption standards is almost the same as that in the EU from 2015 to 2020. Another factor is economic fines for exceeding CO_2 standards, which the EU implements for violators, but China hasn't implemented yet. These factors give the multinational carmakers more leeway to slow the progress on fuel efficiency in China.

Fuel-efficiency technologies and their uneven application across borders also affect carmakers' carbon emission performance between China and the remaining regions. A study from ICCT found that though China's penetration of fuel-efficiency technologies has increased, some fuel-efficiency technologies are currently available in other markets but not in China[51]. Even with some mature technologies, the manufacturer's adoption of them is still slower than those in the EU and USA. For example, Hyundai has different adoption strategy of Gasoline Direct Injection (GDI), a technology which could help increase the fuel efficiency in different markets. The company had much higher growth rates of GDI adoption in the USA (19%) and the EU (8%) than in China (2%) from 2010 to 2014. [52].

A car's curb weight is highly correlated with fuel consumption rate and 1% increase in curb weight results in a 0.69% increase in fuel consumption rate, all else held equal[53]. China's production-weighted passenger vehicle curb weight increased by 13.1%, from 1,222kg in 2009 to 1,382kg in 2016[54]. The increasing curb weight may be mainly because of the growth of SUVs and MPVs. The SUVs and MPVs stock increased from 10.3% and 4.3% in 2012 to 20% and 6.9% in 2016, respectively[55]. In 2018, China sold 10.35 million SUVs and was the world's largest SUV market[56]. To reduce the carbon emissions of China's passenger vehicles, carmakers need to address the SUV trend and provide consumers with more options of high fuel-efficiency or pure battery models as well as other measures.

05 Recommendations

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Carmakers:

1. Carmakers should comply with the carbon emission standards for passenger cars in each market, even in the regions where the penalties for non-compliance are relatively light.

2. Given carmakers' ability to lower the CO_2 emissions significantly in the EU, carmakers' should adopt more fuel efficient technologies or electrification of passenger vehicles to lower their CO_2 emissions close to the EU level in the less regulated regions.

3. Carmakers have the responsibility to address the SUV trend, which has been proven to contribute significantly to climate change.

Policymaker:

1. Given the positive impacts of progressive regulations on carbon emission reduction, each government should tighten up the carbon emission standards for passenger cars and enforcement. Thus far, only tight standards along with effective enforcement can ensure that carmakers deliver sustained CO_2 emissions reduction.

2. Given carmakers' frequent failure to meet carbon emission standards, the government should impose high penalties for non-compliance.

3. Discourage the procurement of SUVs, such as by increasing the tax on SUVs purchase

4. Encourage the public to choose climate-friendly travel modes by using subsidies and improving public transportation.

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   b) China's Fuel consumption evaluation methods and targets for passenger cars
   c) EU's CO_2 emission performance standards for cars and vans: https://ec.europa.eu/clima/policies/transport/vehicles/regulation_en

   Notes:
   a) For US's 2025 target, the Biden administration revised 2020 SAFE rule and the proposed rule has not been finalized. So, this part will not consider the U.S's 2025 target. (See https://www.govinfo.gov/content/pkg/FR-2021-08-10/pdf/2021-16582.pdf)
   b) Since China has not yet specified the carbon emission standards for passenger cars. The Chinese CO_2 standards used in this report refer to the corresponding CO_2 standards derived from the conversion of China's fuel consumption standards through converting fuel economy into CO_2 emission values.
   c) We translate the fuel economy(L/100km) to CO_2 emission by the equation: R=T*23.7. Here T refers the fuel economy and R refers to CO_2 emission (See https://www.miit.gov.cn/n1146285/n1146352/n3054355/n3057585/n3057592/c6616416/part/6616424.pdf)
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28. Source: data from EPA report (The EPA Automotive Trends Report from 2018-2020)
    Notes:
    a) To assess if the carmakers comply with US emission standards, the report adopts the performance value from car to evaluate it. And then we compare their car fleet standards to their respective performance values.
    b) USA classifies the light-duty vehicle into car and truck, and the car-truck classifications in the EPA report follows the current regulatory definitions used by EPA and NHTSA for compliance with GHG emissions and CAFE standards (see definitions for passenger automobiles (cars) and non-passenger automobiles (trucks) in 49 CFR 523). For this reason, this report only considers carmaker's compliance with the CO2 standards for car.
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    a) Since the carmakers' compliance with U.S CO_2 standards in 2020 are not available yet and VW underwent an investigation in 2016 and its CO_2 emissions in 2016 could be corrected later (See EPA's Greenhouse Gas Emission Standards for Light-Duty Vehicles in 2016), the report does not include the data about average CO_2 emission from manufactures in 2016 and 2020.
    b) The manufacturers' CO_2 performance here refers to the performance value from car in EPA's automotive trends report.
    c) Due to the predominance of gasoline cars in the U.S, the report uses the conversion coefficient for gasoline cars to translate manufactures' CO_2 emission data under US test cycle into CO_2 emission values under NEDC (See Development of test cycle conversion factors among worldwide light-duty vehicle CO_2 emission standards, The International Council on CleanTransportation, September 2014).
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    a) Because EEA's report has not published the average CO_2 emissions from the car pool 2018, the report adopted the results from Transport & Environment, whose definition of car pool is almost the same as the EEA's report and also consider the Impact of flexibility mechanisms such as super-credits and Eco-innovations. So the difference between EEA's and T&E's calculation is insignificant.

b) Since EEA's report in 2017 has not calculated separately the average CO_2 emission from Kia pool and Hyundai pool, the report adopted the results for Kia and Hyundai from ICCT's report, which considered the impact of flexibility mechanisms. And its definition of car pool is close to EEA's report. So the difference between EEA's and ICCT's calculation is insignificant.

c) Manufactures might modify their car pools during the time. For example, Toyota used the single pool in 2016 and 2017 but they form a car pool with Mazda since 2018. And similarly Hyundai and Kia formed a car pool in 2017 while they form the car pool separately for the rest of time. This research tried to use the data about the car pool except the case of Hyundai-Kia. This research divided Hyundai-Kia pool in 2017 into two car pools for the purpose of comparison.

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Notes:

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b) Due to the predominance of gasoline cars in the U.S, the report uses the conversion coefficient for gasoline cars to translate manufactures'CO2 emission data under USA test cycles into CO2 emission under NEDC. (the conversion coefficient see: Development of test cycle conversion factors among worldwide light-duty vehicle CO2 emission standards. KÜHLWEIN, J., GERMAN, J., & BANDIVADEKAR, A. 2014)

36. Note:
Due to flexibility mechanisms such as E-innovation, super-credit and so on, the official data might be lower than the actual CO2 emission and the reduction rate might be different based on actual CO2 emissions. (See https://www.greenpeace.de/sites/www.greenpeace.de/files/s03501_gp_co2_loopholes_3_2021_3.pdf)

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The data about carmakers' CO_2 performance in 2020 are from ICCT's report CO_2 emissions from new passenger cars in Europe: Car manufacturers' performance in 2020, 2021, 08
Note:
Honda has formed a car pool with FCA and Tesla, their own CO_2 performance are not available yet. So the report has not added Honda's 2020 data in.

38. Here, we average the reduction rates made by all joint ventures owned by each manufacturer group and use it to represent the reduction rate made by the group

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