GREENPEACE

Big Cars, Bigger Crisis

A comparative analysis of carbon dioxide emissions and sport utility vehicle sales by five automakers

CONTENTS

1.

Introduction

1. Introduction

The auto industry is a major emitter of greenhouse gases (GHG). In 2022, 17.9% of GHG emitted globally were produced by ground transportation including passenger and freight vehicles.[1] As of 2018, passenger vehicles were responsible for 45% of GHG emissions in the transport sector.[2] Greenpeace urges that automakers cease the sale of new internal combustion engines (ICE) vehicles – including hybrid vehicles – by 2030. Automakers are also asked to diversify their business models from focusing on the manufacturing and sale of vehicles to offering alternative mobility solutions such as car sharing. Implementing measures to reduce vehicle emissions and promoting alternative travel solutions (active travel and public transport) will help to alleviate problems associated with air pollution and traffic congestion, as well as bringing co-benefits through stopping the burning of fossil fuels, ultimately benefiting the environment and human health. Unfortunately, automakers' responses to calls to develop alternative travel solutions have been slow, which is delaying the greener, cleaner, and safer future we deserve.[3]

This report presents an analysis of data compiled from five top automakers that posted the highest sales volume globally in 2022: Toyota, Volkswagen, Hyundai Motor Group (Hyundai-Kia), Stellantis and General Motors (GM). These five automakers are responsible for almost half (roughly 43%) of total global sales volume.

Hyundai Motor Group, Korea's primary automaker, has announced its plan to invest almost KRW 63 trillion domestically through 2025 to pursue initiatives that will serve as a 'hub of the group's future business'.[4] However, more than 60% of the pledged investment is earmarked for improving the product quality of ICE vehicles.[i] Focusing its product portfolio on a fleet of sport utility vehicles (SUVs) as a part of its strategy to improve profitability has put Hyundai Motor Group's sustainability plan under scrutiny. In 2022, SUVs accounted for more than half (52.7%) of Hyundai-Kia's total global vehicle sales.

i Hyundai Motor Company has noted that almost KRW 38 trillion, or nearly 60% of the KRW 63 trillion plan, will be invested to improve product quality of ICE vehicles and customer service.

A product portfolio that focuses on an SUV fleet poses a serious threat to the climate crisis because of the high levels of CO_2 emissions from those vehicles. The carbon footprint of an SUV throughout its life-cycle – from manufacturing to operation on the road – is significant because it produces substantial CO_2 emissions. SUVs are generally heavy-duty vehicles that require bigger engines and more steel than sedan models. According to a report by the European Environment Agency (EEA), a rise in the use of heavy-duty SUVs was associated with an increase in average CO_2 emissions from all new cars in European Union (EU) countries from 2017 to 2019.[5] The increase in SUV popularity continued from 2020 to 2022, when 10 out of 15 major automakers posted continued growth of SUV sales globally.[6] Globally, the SUV fleet grew from less than 50 million in 2010 to 330 million in 2022[7], an increase that outnumbers all vehicles registered in the EU by 1.3 times.[8]

If SUVs were a country, they would have had the sixth highest absolute emissions in the world in 2021, at more than 900 million tonnes of CO_2 which is more than the total emissions of Germany.

The IEA has released a number of reports that shed light on the impact of the SUV fleet on the environment[7 10] but has yet to report a detailed breakdown by automaker. This report attempts to analyze SUV sales data from the major automakers and corresponding tailpipe CO_2 emissions to investigate the validity of automakers' plans for pushing zero-emission vehicles (ZEV) to achieve carbon neutrality and call for more aggressive actions toward sustainable mobility strategy for the future.

This report contains the following findings:

1. **Analysis of SUV sales trends of the top five automakers.**
2. **Analysis of tailpipe CO_2 emissions of five automakers.**
3. **Analysis of tailpipe CO_2 emissions trends of five automakers in 2017 and 2022.**
4. **Analysis of the impact of ZEVs on CO_2 emissions reduction in 2022.**

2.

SUV Overview

2.1
SUV – definition and features

Sport utility vehicles (SUVs) are vehicles designed with greater emphasis on uses such as sporting and leisure activities. SUVs typically have higher ground clearance than sedans to facilitate off-road usage. While the definition of SUV may differ by country, the IEA adopts a broader range including any and all sedans equipped with off-road features for the purpose of its analysis. For this report, the definition of an SUV is limited to large SUVs and the small SUV known as the crossover utility vehicle (CUV) and excludes multi-purpose vehicles (MPVs) and pick-up trucks.[ii] SUV sales data from each automaker is collected as presented by MarkLines that applies the same definition.

2.2
The carbon footprint of an SUV

The carbon dioxide (CO_2) emissions of an SUV throughout its lifecycle, from manufacturing to operation on the road, are significant. Typical sedans comprise around 60% of steel by weight using an average of 900 kg of steel. In comparison, SUVs use an average of 20% more steel than an equivalent size sedan.[11] With an estimated 1.4 tonnes of carbon dioxide equivalent emissions (CO_2-eq) during the process of producing 1 tonne of steel[12], the increased sales numbers of SUVs inevitably leads to increased CO_2 emissions.

SUVs tend to be heavier and consume more energy for operation than typical sedans because they are built using more steel. According to IEA research, global oil consumption by SUVs accounted for one-third of the total growth in oil demand in 2021 and 2022 while oil consumption by sedans remained roughly the same.[7] SUVs consume an average of around 20 to 25% more oil than sedans, therefore increasing the SUV fleet in the market will lead to increased CO_2 emissions. The IEA noted that the number of SUVs increased by almost 35 million throughout 2021, leading to an increase of CO_2 emissions by 120 million tonnes.[10]

Although SUVs slow the decarbonizing efforts by the auto industry, the continued growth in the SUV market is not showing any signs of wavering and is particularly noticeable in certain countries. On average, Global North countries posted five times higher SUV sales per capita than Global South countries and emerging markets in 2021, signaling the need to remind Global North countries to take more aggressive actions towards reducing CO_2 emissions given that the headquarters of many multinational corporations are in these countries.[13]

ii Definition of SUV is adjusted from IEA definition to facilitate effective application of sales data by MarkLines and EPA.

3.

Analysis of SUV sales

3.
Analysis of SUV sales

This report breaks down the sales data of SUVs from 2013 to 2022 relative to all vehicles, ICE vehicles and zero-emissions vehicles (ZEVs). Data used for the analysis was compiled from the five automakers that posted the highest sales volume globally in 2022: Toyota, Volkswagen, Hyundai Motor Group (Hyundai-Kia), Stellantis and General Motors (GM). These five companies account for almost half (roughly 42%) of total global sales volume.

3.1
SUV sales trends

3.1.1. SUV sales as a proportion of total vehicle sales

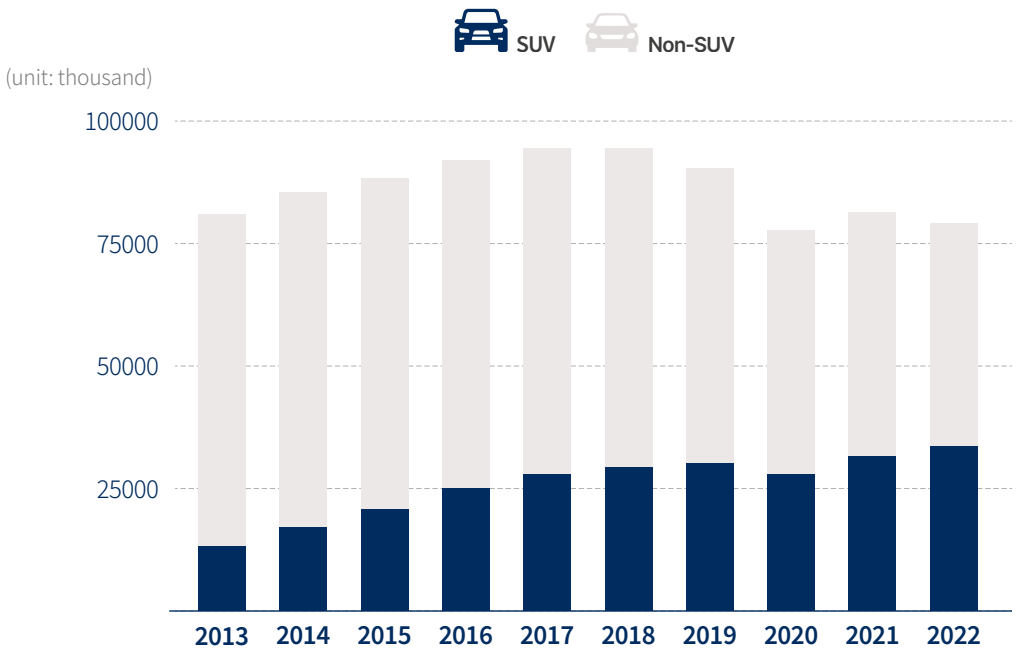
Sales of SUVs have seen sharp growth globally. The number of new SUVs sold recorded 12.72 million in 2013, and sales figures soared by 154.7% to 32.40 million in 2022. Industry-wide, 2017 and 2018 marked the time when the total car sales took a downward turn, dropping from 92.66 million units in 2017 to 79.47 million (a 14.2% decrease) in 2022. Even when the auto industry as a whole suffered a huge setback from the COVID-19 pandemic in 2020 and total car sales plummeted by 13.4% from the previous year, SUV sales fell by just 6.7%. Strong performance of SUVs is clearly demonstrated in its sales volume when compared to total sales volume of all vehicles. The share of SUVs in the market steadily grew from 15.4% in 2013 to more than 40% in 2022.

[TABLE 1]
Global SUV sales trend
(2013 to 2022)

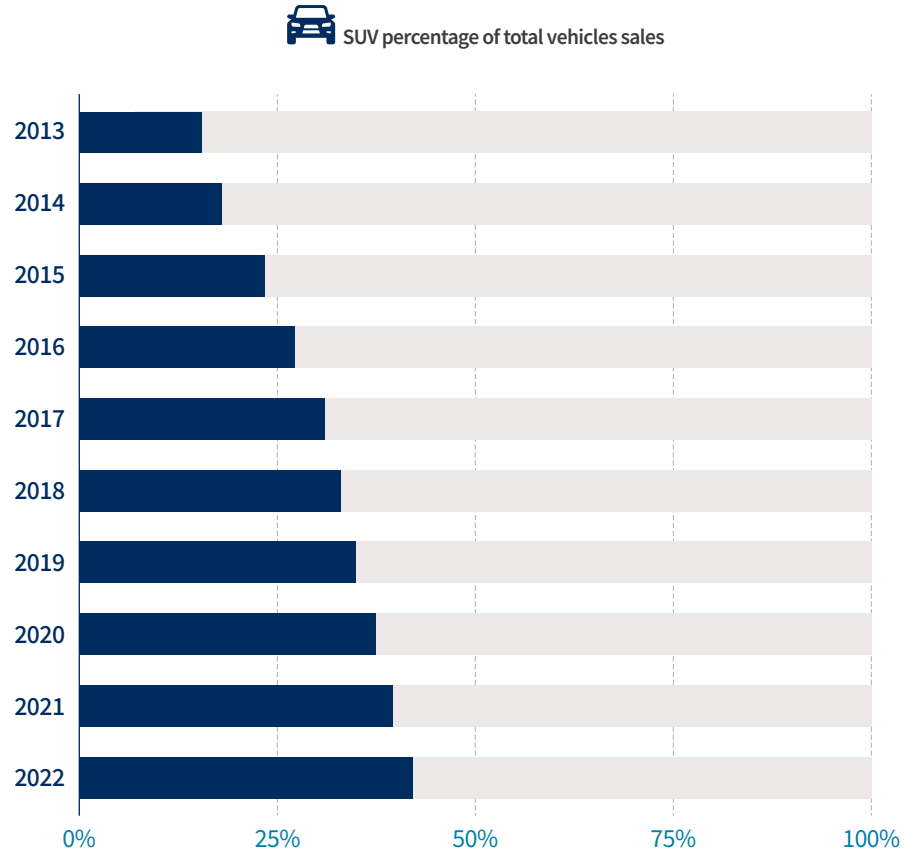
(unit: thousand)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
SUV	12723	15646	20361	24732	27669	29222	29671	27672	30908	32400
All Vehicles	82535	85343	87400	91458	92656	92654	89013	77054	80377	79474
Ratio of SUVs	15.4%	18.3%	23.3%	27.0%	29.9%	31.5%	33.3%	35.9%	38.5%	40.8%

[FIGURE 1]
Global SUV sales trends (2013 to 2022)



[FIGURE 2]
SUV percentage of total vehicles sales (2013 to 2022)



3.1.2. SUV sales as a proportion of total vehicle sales by five automakers

Aggregate sales volumes of the five featured automakers in this analysis decreased by 13.0% from 38.26 million units in 2013 to 33.31 million units in 2022. Although Toyota managed to maintain a steady sales trend (7.8% increase in 2022 compared to 2013), the remaining four automakers exhibited clear signs of declining sales.

All five automakers reported continued growth in SUV sales over the past ten years to 2022. The total sales volumes of SUVs by the five automakers combined increased by 144.3% from 5.73 million units in 2013 to 13.99 million units in 2022. The growth was particularly robust for the top three automakers – Toyota, Volkswagen and Hyundai-Kia – with increases of 158.1% for Toyota, 270.5% for Volkswagen and 152.4% for Hyundai-Kia in 2022 from 2013. These three automakers each posted over 150% growth in SUV sales over the past ten years.

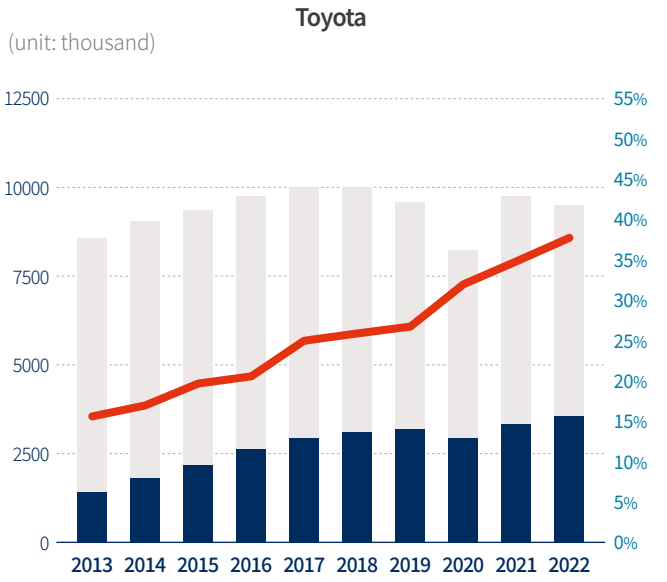
In 2022, Toyota, Volkswagen and Hyundai-Kia each sold around 3.5 million units of SUVs. Stellantis and GM each reported sales of around 1.8 million units. While Volkswagen's SUV sales lagged well behind Toyota and Hyundai-Kia in 2013, with Volkswagen selling just about 1 million SUV units, the firm's sales figures caught up with Toyota and Hyundai-Kia in 2022. Hyundai-Kia's total sales volume fell short of Toyota and Volkswagen, but the firm sold a similar volume of SUVs.

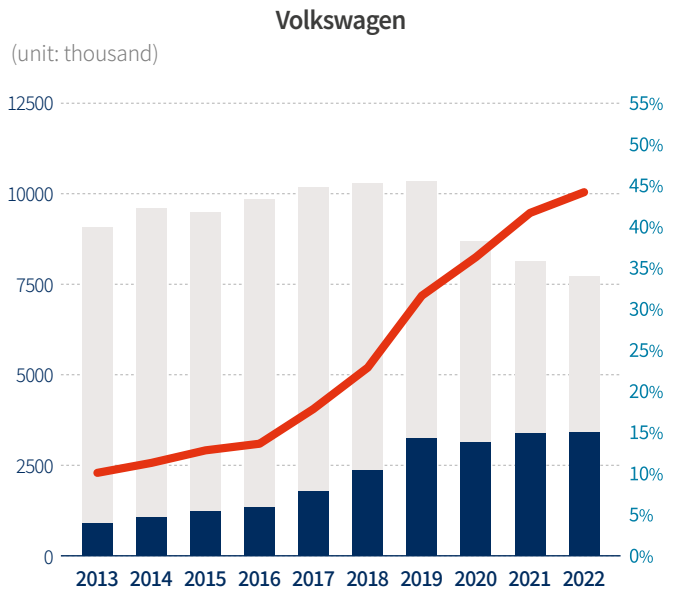
[TABLE 2]
SUV sales compared to all vehicles by five automakers from 2013 to 2022.

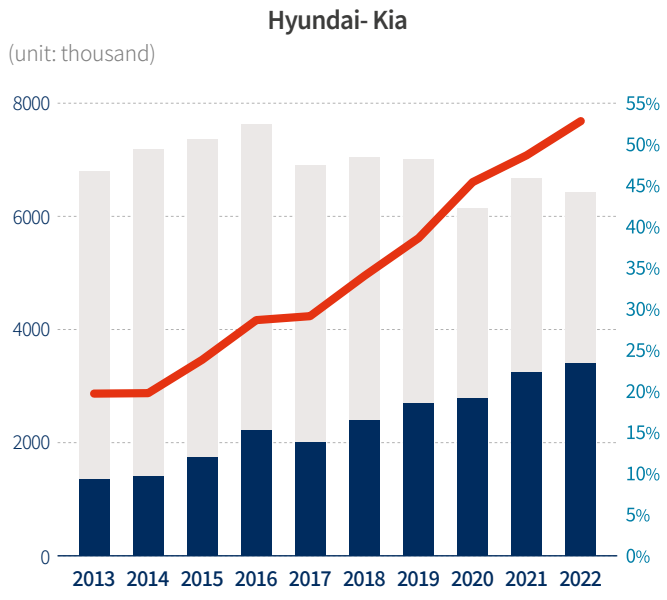
(unit: thousand)

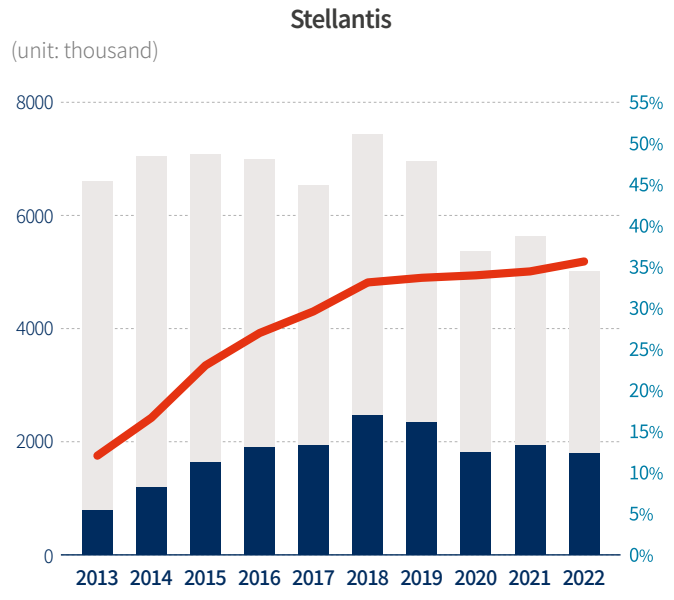
Automaker		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Toyota	SUV	1409	1553	1794	1900	2403	2535	2690	2808	3390	3637
	All vehicles	9039	9288	9294	9464	9711	9870	9971	8732	9732	9748
	SUV Ratio	15.6%	16.7%	19.3%	20.1%	24.7%	25.7%	27.0%	32.2%	34.8%	37.3%
Volkswagen	SUV	923	1094	1228	1345	1823	2369	3270	3154	3399	3420
	All vehicles	9108	9622	9514	9856	10185	10324	10338	8680	8149	7725
	SUV Ratio	10.1%	11.4%	12.9%	13.6%	17.9%	22.9%	31.6%	36.3%	41.7%	44.3%
Hyundai-Kia	SUV	1337	1409	1743	2177	1992	2386	2689	2773	3228	3374
	All vehicles	6799	7167	7364	7629	6872	7044	6989	6128	6656	6404
	SUV Ratio	19.7%	19.7%	23.7%	28.5%	29.0%	33.9%	38.5%	45.2%	48.5%	52.7%
Stellantis	SUV	794	1179	1635	1893	1937	2465	2350	1827	1937	1795
	All vehicles	6604	7068	7075	7016	6523	7438	6965	5378	5615	5026
	SUV Ratio	12.0%	16.7%	23.1%	27.0%	29.7%	33.1%	33.7%	34.0%	34.5%	35.7%
GM	SUV	1264	1392	1701	1808	1895	1921	1969	1910	1753	1760
	All vehicles	6714	6711	6522	6540	6602	6531	6049	5283	4430	4407
	SUV Ratio	18.8%	20.7%	26.1%	27.6%	28.7%	29.4%	32.6%	36.2%	39.6%	39.9%

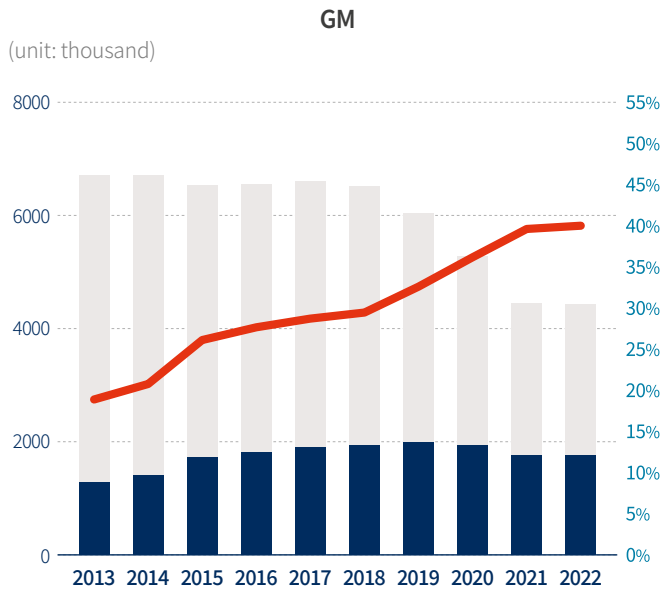
[FIGURE 3]
SUV sales compared to all vehicles by five automakers from 2013 to 2022.





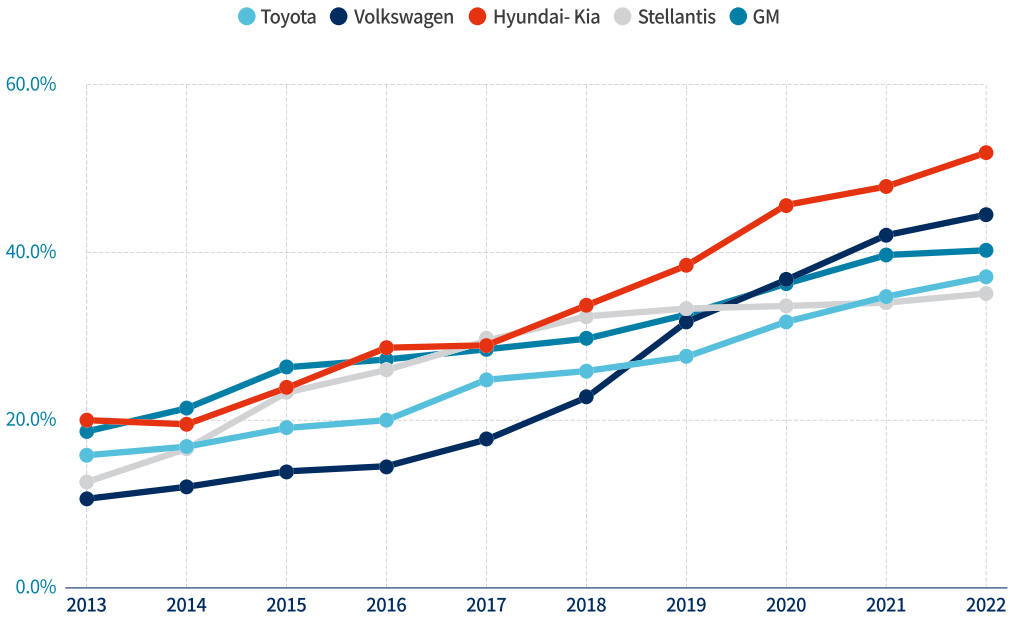






SUV sales have maintained a steady pace of growth (Table 2, Figure 4). **When compared to sales of all vehicles by the five automakers, the ratio of SUVs increased by almost 2.8 times in the past ten years from 15.0% in 2013 to 42.0% in 2022.** Until 2018, Hyundai, Stellantis, and GM had a similar SUV share portion and growth rates. However, after 2018, Stellantis and GM saw their SUV share of total vehicles increase, but the growth rate slowed, whereas Hyundai has seen its share and growth rate continue to increase. Even though the ratio of SUVs increased for Stellantis and GM, the rate of growth slowed down. As of 2022, Hyundai-Kia was the sole automaker out of the five whose sale of SUVs comprised more than half (52.7%) of all vehicles sold. Meanwhile, Volkswagen presented the greatest change in the ratio of SUV sales compared to all vehicles in 2022 compared to 2013, increasing more than 4 times from 10.1% to 44.3%.

[FIGURE 4]
SUV sales trends by automaker from 2013 to 2022.

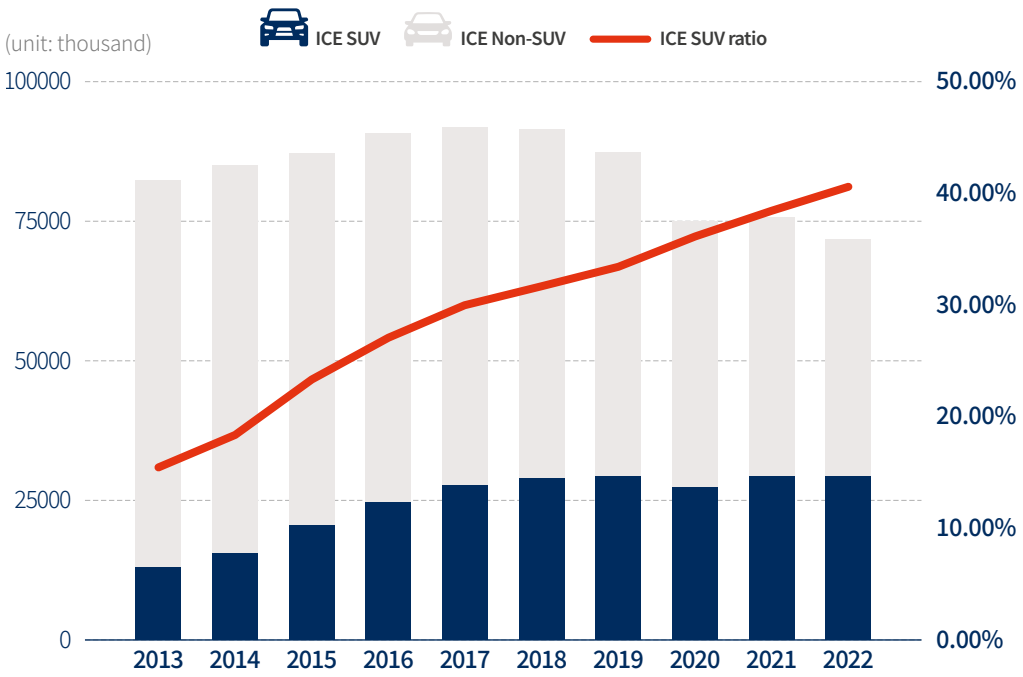


3.2
ICE vehicles: SUV sales trends

3.2.1. SUV sales as a proportion of ICE vehicle sales

The majority of vehicles sold from 2013 to 2022 were ICE vehicles. The ratio of SUV sales compared to all vehicles increased steadily from 15.4% in 2013 to 40.6% in 2022. The sales volume of ICE vehicles peaked at 91.91 million units in 2017 before dropping to 71.69 million units in 2022. During the same period, however, the sales volume of ICE-powered SUVs increased by 5.4% from 27.61 million units in 2017 to 29.09 million units in 2022. **The data reveal that the market for ICE-powered SUVs has not declined despite the fact that other types of ICE-powered vehicles have begun to show clear signs of decline.**

[FIGURE 5]
Sales volume of ICE SUVs compared to ICE vehicles from 2013 to 2022.



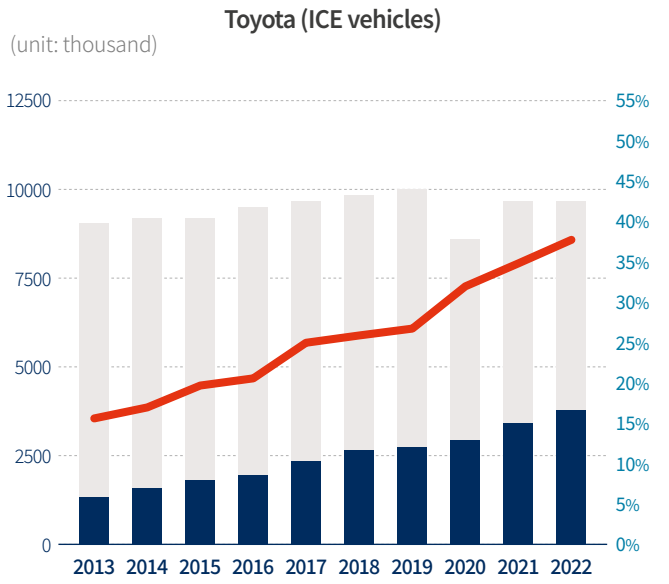
3.2.2. SUV sales as a proportion of ICE vehicle sales by five automakers

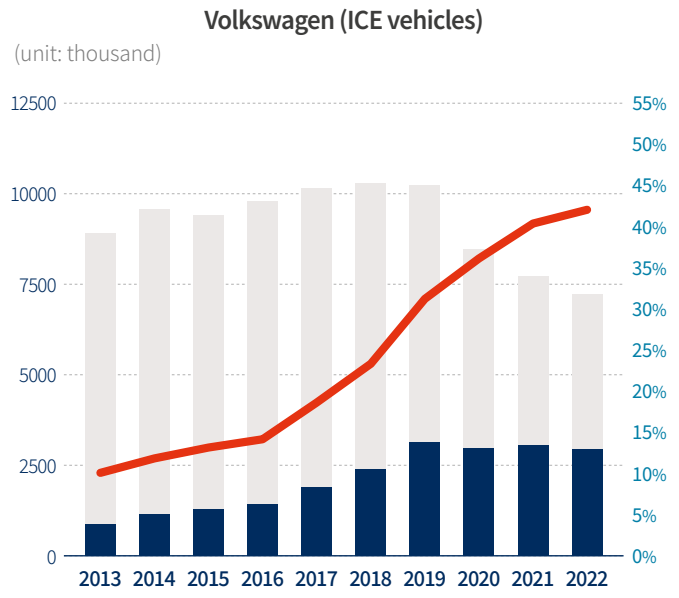
Aggregate sales volume of ICE vehicles by the five automakers in this analysis decreased by 16.3% from 38.26 million units in 2013 to 32.03 million units in 2022. Toyota was the only automaker that maintained a similar sales volume of ICE vehicles to the sales volume trend of all vehicles (7.6% increase in 2022 compared to 2013). All other automakers posted decreasing sales trends of ICE vehicles.

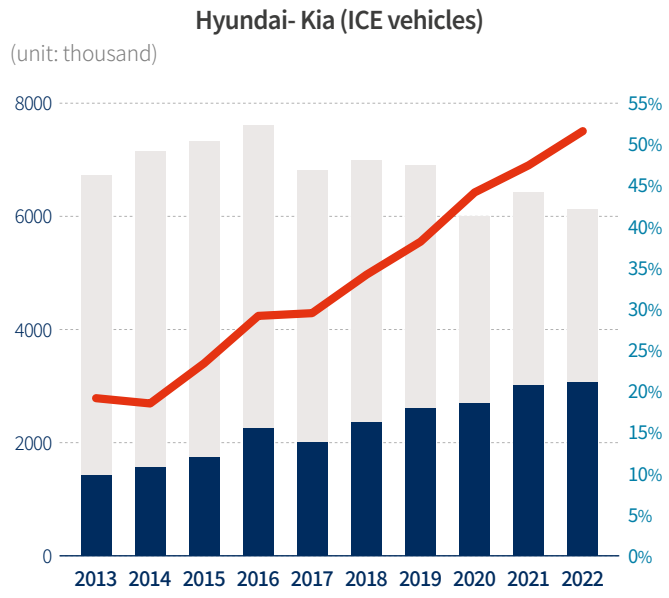
All five automakers performed strongly in the ICE-powered SUV market over the past ten years, reporting a steady pace of increase that jumped by 130.3% from 5.72 million units in 2013 to 13.18 million units in 2022. However, 2018 and 2019 marked the peak for GM and Stellantis, whose ICE-powered SUV sales figures turned downward over the past three years (2020 to 2022). Volkswagen also reported rapid growth through 2019, but has achieved steady growth at about 3 million units annually since 2019. Toyota and Hyundai-Kia maintained an upward sales trend of ICE-powered SUVs over the past three years, with an average increase of 29.1% and 15.0% respectively.

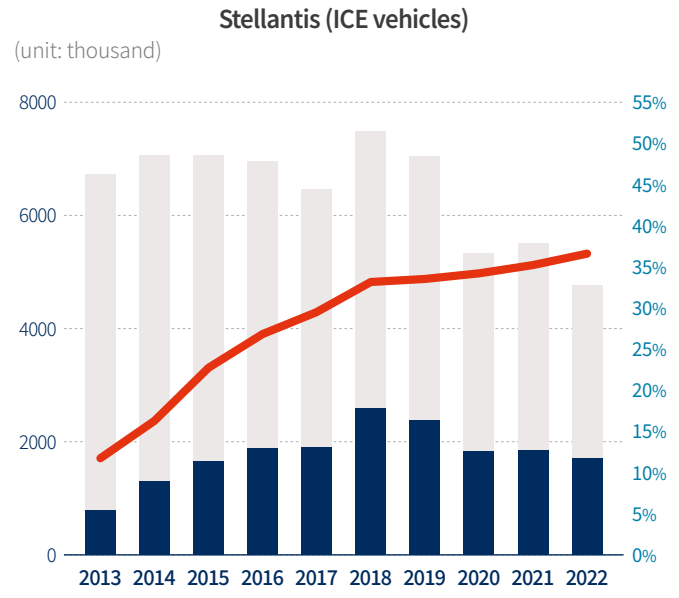
Sales of ICE SUVs by Toyota in 2022 compared to 2017 soared by 50.7%, while sales of all ICE vehicles increased just by 0.17% (Table 3). Volkswagen sold 66.1% more ICE SUVs in 2022 compared to 2017, when sales of ICE vehicles as a whole dropped by 29.6%. Similarly, sales of ICE SUVs also increased by 54.6% for Hyundai-Kia in 2022 compared to 2017 even though sales of ICE vehicles as a whole fell by 11.8%. The sales volume of ICE SUVs decreased slightly in comparison to the same period for Stellantis and GM. **In summary, Volkswagen and Hyundai-Kia greatly expanded their share of ICE SUVs despite a clear decline in total ICE vehicle sales. Toyota also pushed to increase its ICE SUV market by more than 50%, and it also expanded its ICE vehicle market.**

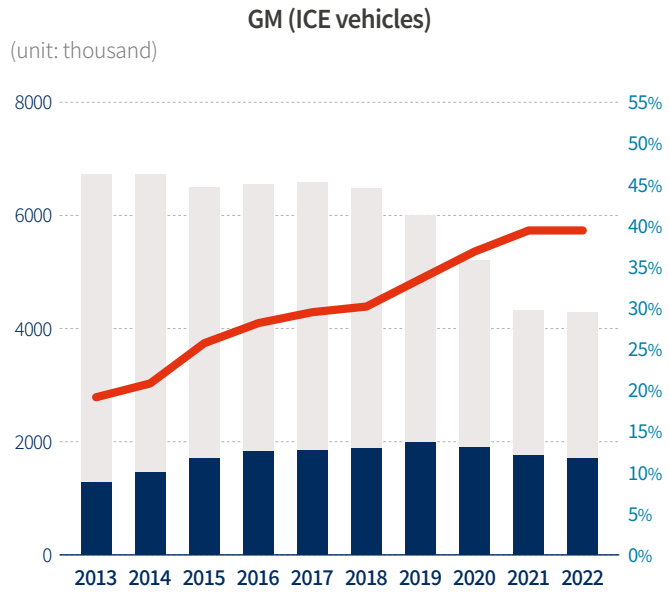
[FIGURE 6]
Sales volume trend of ICE SUV compared to all ICE vehicles by five automakers from 2013 to 2022.











[TABLE 3]
The growth trends of ICE vehicle sales by five automakers from 2017 to 2022.

	All vehicles (ICE)	SUVs (ICE)
Toyota	+ 0.17%	+ 50.73%
Volkswagen	- 29.55%	+ 66.13%
Hyundai-Kia	- 11.76%	+ 54.61%
Stellantis	-26.70%	-10.33%
GM	-34.26%	-9.39%

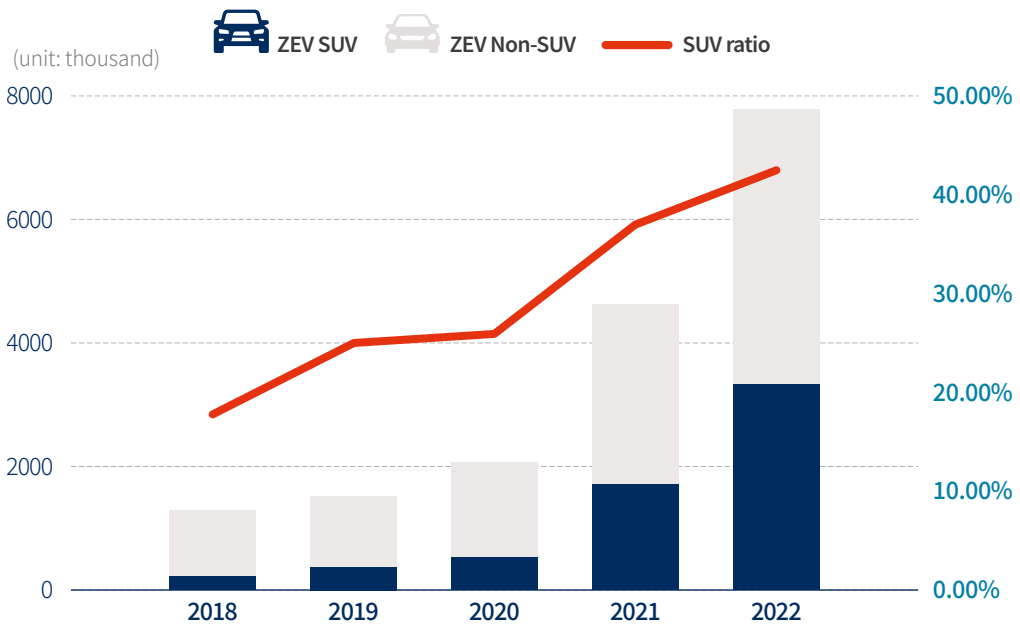
3.3
ZEVs: SUV sales trends

3.3.1. SUV sales as a proportion of ZEV sales

The sales volume of ZEVs is minor compared to ICE vehicles, recording just 0.11 million ZEVs sold compared to 82.54 million total vehicles sold in 2013, and 7.78 million ZEVs sold compared to 79.47 million total vehicles sold in 2022. Even though ZEV sales increased by a four-figure percentage of 7,062.9% during the ten years from 2013 to 2022, the ZEV market share barely scratched 10% of the entire car market in 2022. In order to draw out a meaningful assessment of sales trends of ZEVs, the analysis was limited to the period from 2018 to 2022 during which the sale of ZEVs exceeded 1 million.

Despite the relatively small market share of ZEVs, steady growth of SUVs within the segment should be noted. Only 17.7% of ZEVs sold in 2018 were SUVs, but the ratio increased to 42.5% in just five years. While ZEVs, both sedans and SUVs, do not release tailpipe emissions, SUVs in general tend to leave a greater carbon footprint than sedans during the manufacturing process with their heavier and larger body.

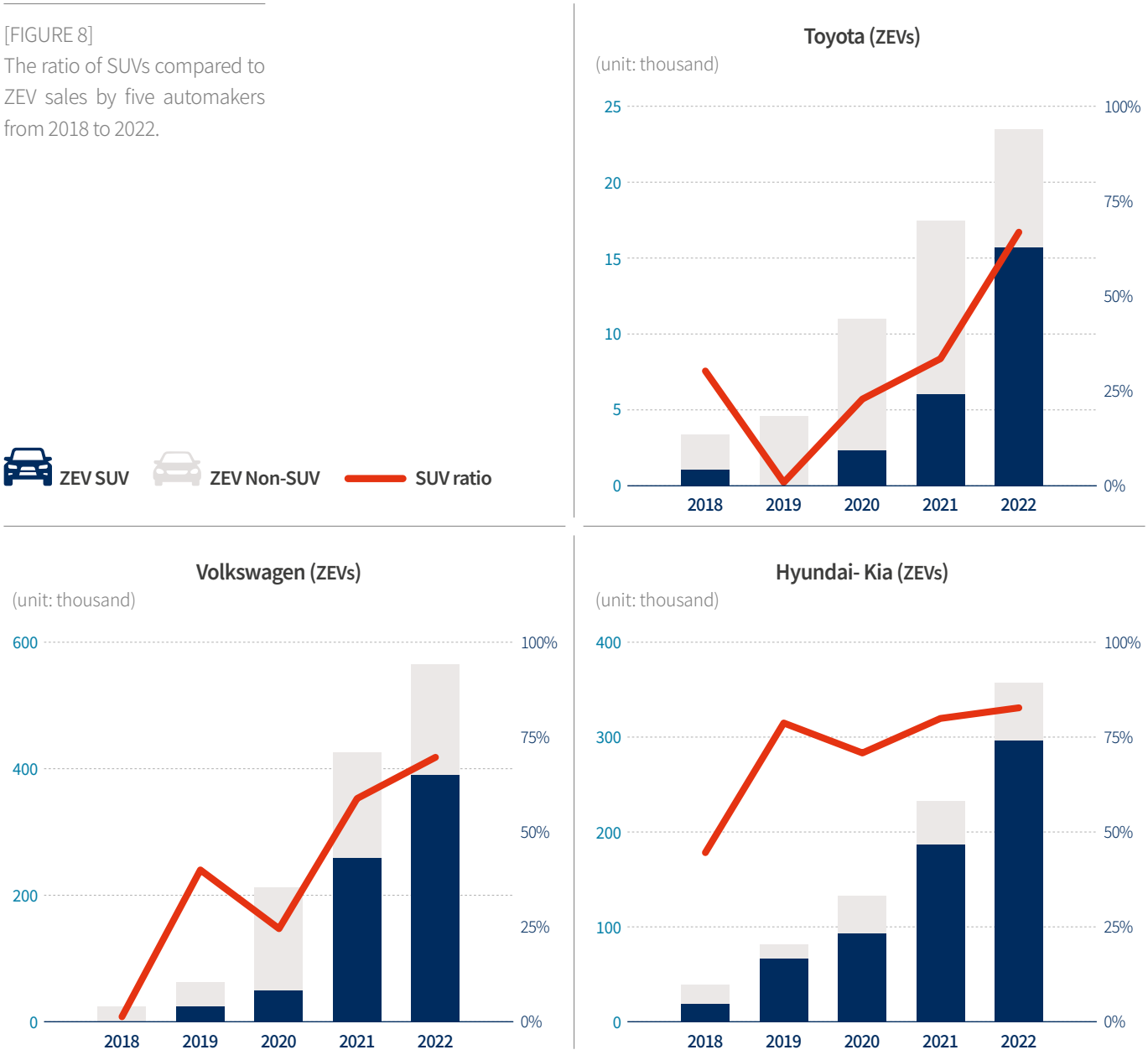
[FIGURE 7]
The ratio of SUV sales compared to ZEV sales from 2018 to 2022.

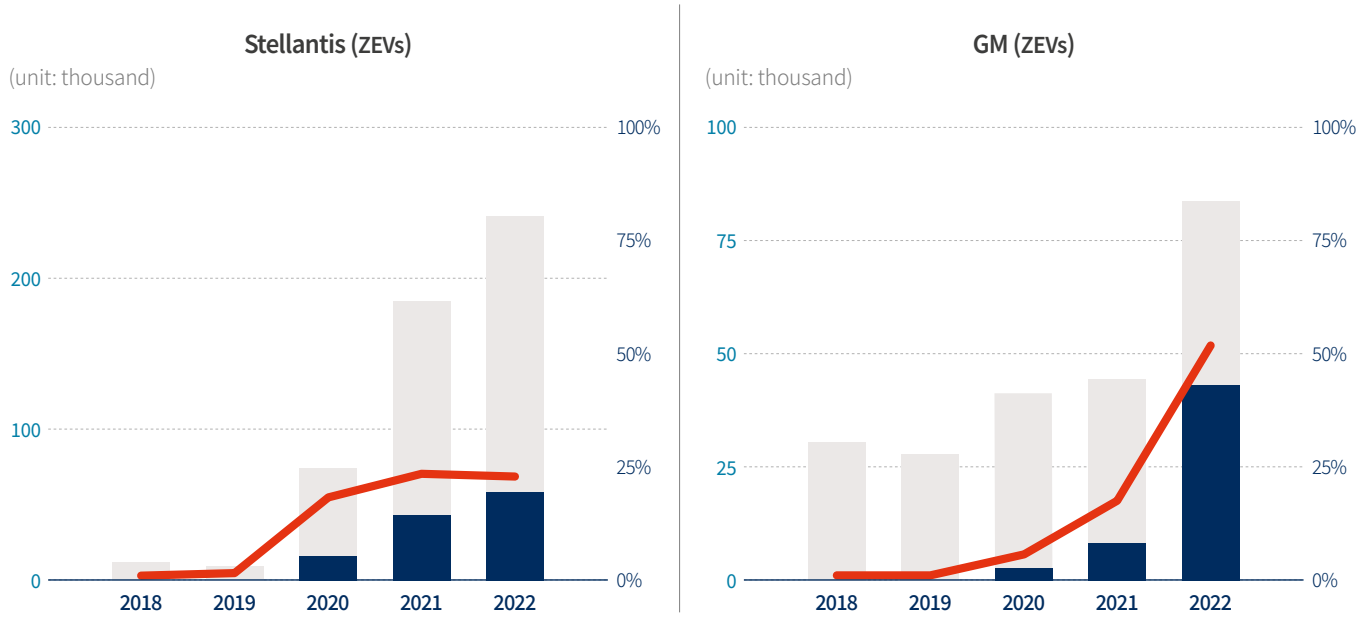


3.3.2. SUV sales as a proportion of ZEV sales by five automakers

The market share of SUVs in the ZEV segment is rapidly growing. For the five automakers, sales of ZEV SUVs grew from 17.8% in 2018 to 62.8% in 2022, which is an increase of almost 45%. In 2022, Toyota, Volkswagen, Hyundai-Kia, GM recorded more than 50% of ZEV sales credited to SUVs. Hyundai-Kia stood out in its rapid expansion of ZEV SUVs, dominating the market in the past five years with 82.7% of its ZEV sales attributed to SUVs.

[FIGURE 8]
The ratio of SUVs compared to ZEV sales by five automakers from 2018 to 2022.




Stellantis (ZEVs)
(unit: thousand)
300
200
100
0
100%
75%
50%
25%
0%
2018
2019
2020
2021
2022
GM (ZEVs)
(unit: thousand)
100
75
50
25
0
100%
75%
50%
25%
0%
2018
2019
2020
2021
2022

4.

Analysis of CO_2 emissions from SUVs

4.
Analysis of CO_2 emissions from SUVs

Data on carbon dioxide (CO_2) emissions from ICE vehicles from 2013 to 2022 by vehicle type (SUV and sedan) was reviewed for analysis. ZEVs were excluded from the analysis because they do not release tailpipe emissions. Pick-up trucks and MPVs were not included because they are not classed as SUVs in this study.[iii] The analysis determined the number of vehicles sold by the five automakers operating on the road in 2017 and 2022. The numbers were multiplied by the annual CO_2 emissions data of each automaker to compare 2017 and 2022. This makes it possible to see how CO_2 tailpipe emissions are changing in line with the previous analysis of ICE SUVs, which continued to grow despite the downward trend in overall ICE vehicle sales. Finally, the status of tailpipe CO_2 emissions of the five automakers and the reduction, if any, attributed to the growth of ZEVs in 2022 was analyzed.

4.1
Calculation of tailpipe CO_2 emissions by vehicle type

The United States Environmental Protection Agency (US EPA) releases tailpipe CO_2 emissions data (real-world CO_2, g/mi) of SUVs and sedans of each automaker by model and model year.[14] [iv] [v] The data were used to calculate the average tailpipe CO_2 emissions (g/km) and aggregate CO_2 emissions per 200,000 km.[3] Assuming an average lifespan of a vehicle to be 10 years and the lifetime driven distance of 200,000 km, aggregate CO_2 emissions for 10 years were calculated and divided to estimate an annual average.

It should be noted, however, that the US EPA data required adjustment to estimate the true CO_2 emissions data attributed to ICE vehicles only since it reflects average CO_2 emissions for ICE vehicles and ZEVs combined.

iii Combined number and total CO_2 emissions of SUVs and sedans may not be regarded as an aggregate of total passenger vehicles.

iv Based on the US EPA classification, data applicable to vehicles classified as “Car” in the “Regulatory Class” and identified as “Car SUV” in the “Vehicle Type” was used to represent SUVs, while data applicable to vehicles identified as “Sedan/Wagon” in the “Vehicle Type” was used to represent sedans.

v The data are based on vehicles in the U.S. domestic market and do not precisely match the emissions from each carmaker’s global sales. However, the EPA is the only reliable source that has analyzed average emissions by carmakers according to vehicle type, and the U.S. is a major market for the five carmakers (22% of total sales).

To make the adjustment, data on annual vehicle sales identified by powertrain types was reviewed. The US EPA identifies seven types of powertrains: gasoline, diesel, electric, gasoline-hybrid, plug-in hybrid electric (PHEV), fuel cell vehicles (FCEV) and others (including CNG-powered). EVs and FCEVs were excluded since they are classified as ZEVs.

ZEV ratio = EV ratio + FCEV ratio

Tailpipe CO_2 emissions by ICE were calculated as follows.

Tailpipe CO_2 emissions by ICE (g/mi) = aggregate tailpipe CO_2 emissions (g/mi) / (1 - ZEV ratio)

The following calculation was used for metric conversion.

Tailpipe CO_2 emissions by distance (g/km) = aggregate tailpipe CO_2 emissions by ICE (g/mi) / 1.60934(km/mi)

Tailpipe CO_2 emissions for lifetime mileage (tonnes) = tailpipe CO_2 emissions by distance (g/km) × 200,000 km/1,000,000 (g/tonne)

4.1.1. Comparison of CO_2 emissions: SUVs versus sedans

[FIGURE 9]
CO_2 emissions per driving distance by vehicle type (ICE)

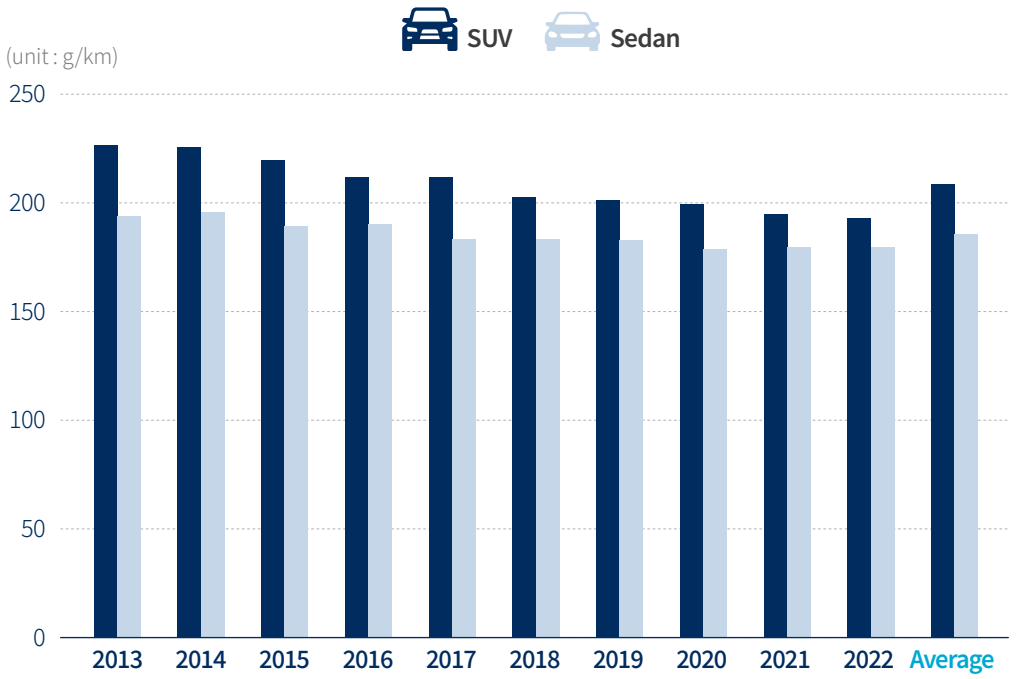


Figure 9 on CO_2 emissions from 2013 to 2022 by vehicle type demonstrates that SUVs are responsible for greater CO_2 emissions than sedans. Average CO_2 emissions by SUVs during the period was 209.1 g/km, which is 23.2g more per kilometer than 185.9 g/km emitted by sedans. Figure 9 also exhibits a downward trend of CO_2 emissions, due to factors including improved fuel efficiency made possible by technological advancement, and reduced weight of vehicles.

[FIGURE 10] Total CO2 emissions for lifetime mileage of 200,000 km (ICE)

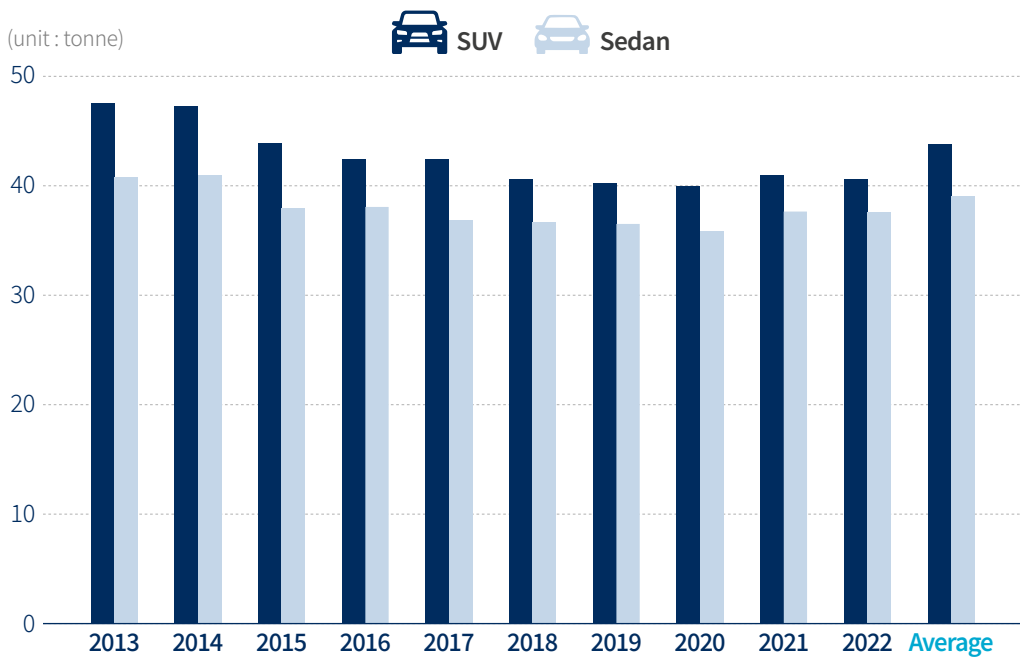
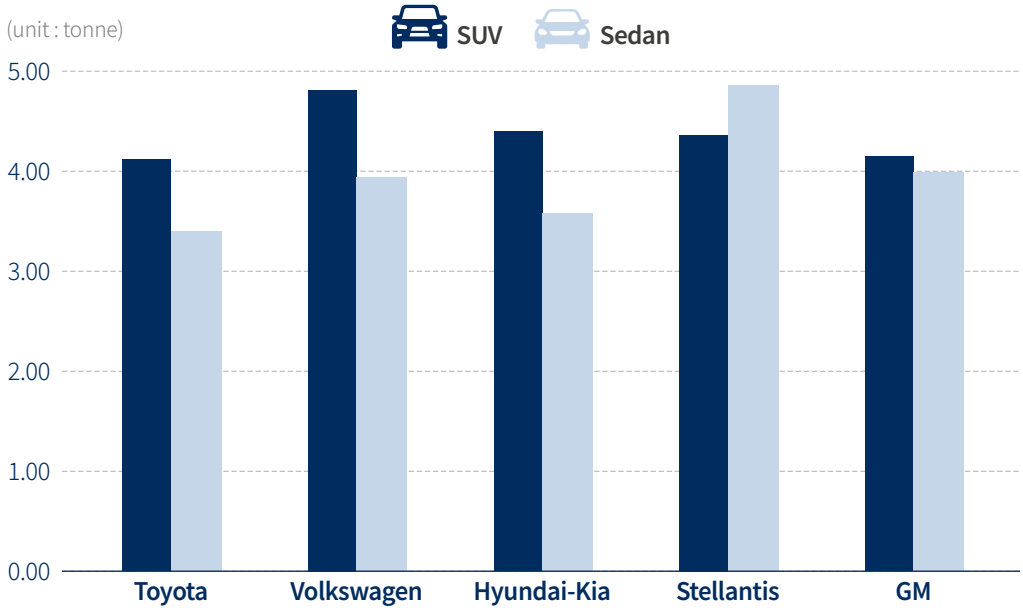


Figure 10 presents CO_2 emissions by vehicle types for a lifetime mileage of 200,000 km, which averages 41.8 tonnes for ICE SUVs and 37.2 tonnes for ICE sedans. In short, SUVs emit 4.6 more tonnes of CO_2 than sedans during their lifespan.

4.1.2. CO_2 emissions from SUVs and sedans sold by five automakers

SUVs made by Volkswagen and Hyundai-Kia recorded the highest average annual CO_2 emissions per kilometer. One ICE-powered SUV made by each automaker, on average, was responsible for 239.1 g/km (Volkswagen) and 220.5 g/km (Hyundai-Kia) of CO_2 emissions annually from 2013 to 2022. Based on an assumption that a vehicle drives 20,000km per year, SUVs made by Volkswagen and Hyundai-Kia released, on average, 4.8 tonnes and 4.4 tonnes, respectively, every year.

[FIGURE 11]
Average annual CO_2 emissions (mileage of 20,000 km) by ICE vehicles made by five automakers between 2013 and 2022.

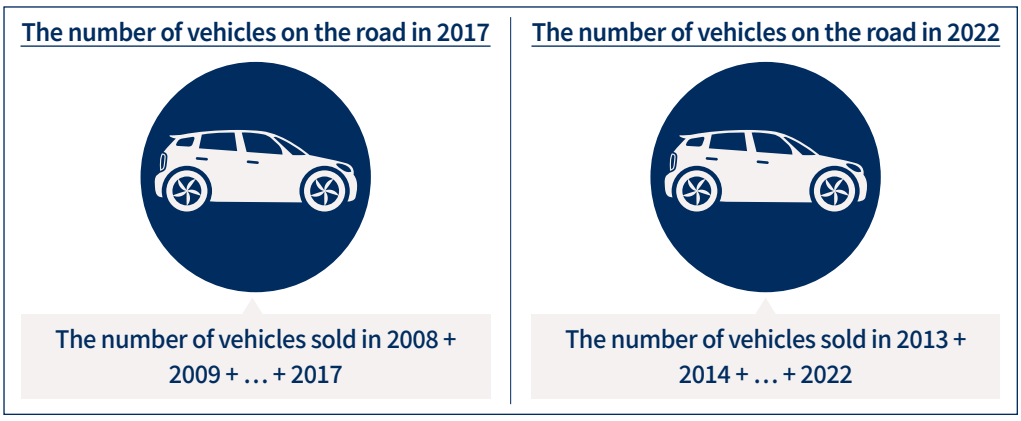


The SUV fleet of all automakers (with the exception of Stellantis) had higher CO_2 emissions when compared to the sedan fleet of the same automaker (Figure 11). The reason Stellantis reported higher CO_2 emissions from its sedans than SUVs is that the sedans that had been the major fleet of Stellantis tend to be heavier and perform with lower fuel efficiency than SUVs, despite being classified as 'sedan/wagon' in recent years.[vi] When it comes to the difference in CO_2 emissions between the SUV fleet and the sedan fleet of the same automaker, Volkswagen and Hyundai-Kia reported a significant variation. From 2013 to 2022, SUVs reported higher CO_2 emissions than sedans with 42.2 g/km for Hyunai-Kia and 41.6 g/km for Volkswagen. Assuming a car drives 200,000km during its lifetime, a fleet of SUVs from Hyundai-Kia would release 8.4 more tonnes of CO_2 than a fleet of sedans. Similarly, SUVs from Volkswagen would produce 8.3 more tonnes of CO_2 than sedans.

4.2
Number of vehicles on the road sold by five automakers

The number of vehicles on the road by each automaker was calculated for 2017 and 2022. The results were used for the calculation of tailpipe CO_2 emissions that was presented in section 4.3. Using the number of cars on the road is a better marker for obtaining accurate tailpipe CO_2 emissions than the number of new cars sold.

The parameters of a ten-year lifespan and a lifetime mileage of 200,000 km per vehicle was also used as an assumption for the calculation of vehicles on the road. The number of vehicles on the road in 2017 was calculated by adding the number of vehicles sold from 2008 to 2017. The number of vehicles in 2022 was calculated by adding the number of vehicles sold from 2013 to 2022. The number of used cars was not factored into the calculation for the purpose of this analysis.



vi In other words, SUVs have higher CO_2 emissions because they are on average heavier and consume more fuel than typical sedans. Even if a vehicle is classified as a sedan, its CO_2 emissions can increase depending on its body weight and fuel consumption.

4.2.1. Number of ICE vehicles on the road sold by five automakers

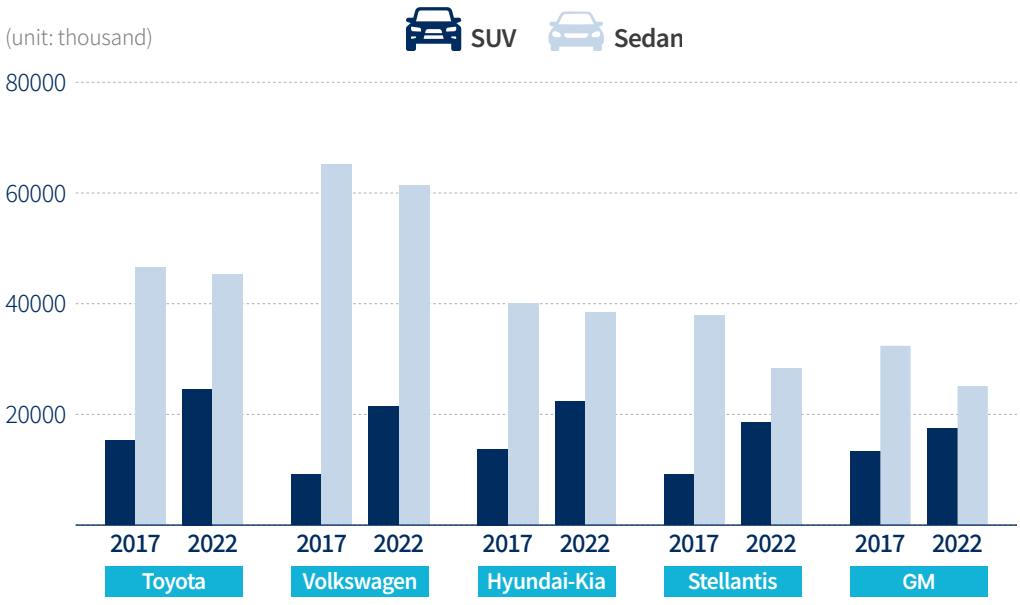
While the number of ICE sedans in 2022 decreased from 2017 for all five automakers, the number of ICE SUVs increased for all five automakers. The rate of decrease ranged from -1.1~-3.4% for Toyota, Volkswagen and Hyundai-Kia, which was relatively marginal compared to Stellantis (-26.1%) and GM (-18%) but in line with the industry-wide trend for ICE vehicles. On the contrary, the number of ICE SUVs in 2022 compared to 2017 posted significant increases for all five automakers, with a rise of 144.5% for Volkswagen, 82.8% for Stellantis and 70.9% for Hyundai-Kia.

(unit: thousand)

[TABLE 4]
The number of ICE vehicles of five automakers in 2017 and 2022.

Automaker		2017	2022	Rate of change
Toyota	SUV	14375	24094	67.61%
	Sedan	47483	46962	-1.10%
Volkswagen	SUV	8712	21300	144.49%
	Sedan	63906	61706	-3.44%
Hyundai-Kia	SUV	13138	22452	70.90%
	Sedan	39753	38526	-3.09%
Stellantis	SUV	9682	17696	82.77%
	Sedan	38478	28199	-26.71%
GM	SUV	12555	17319	37.95%
	Sedan	31743	26026	-18.01%

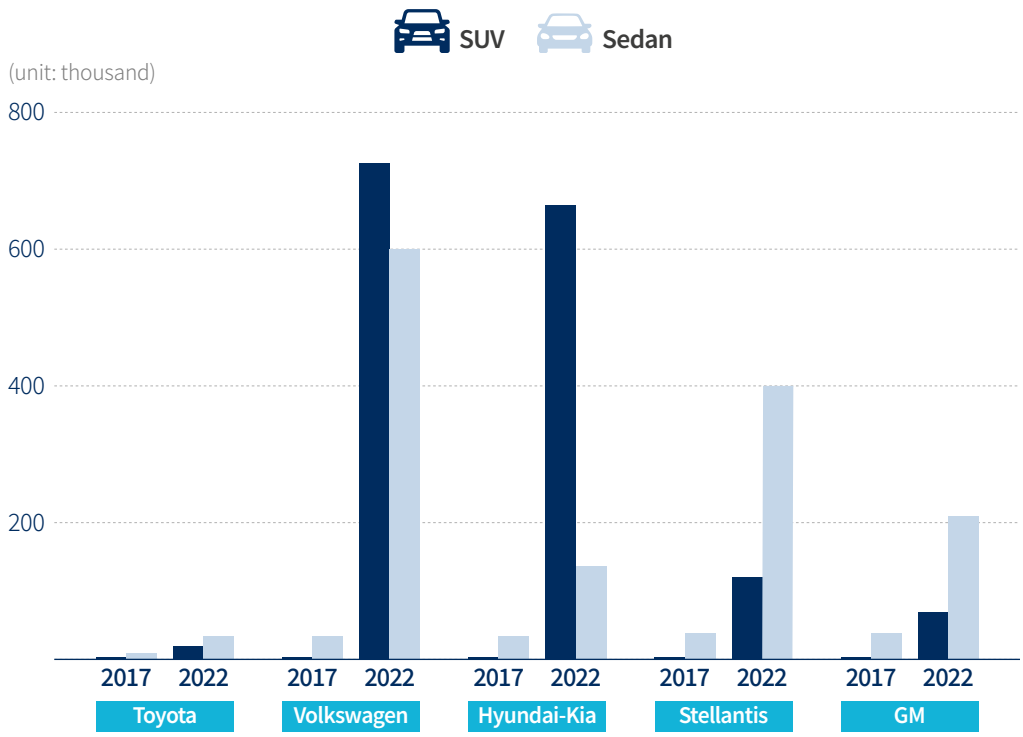
[FIGURE 12]
The number of ICE vehicles of five automakers in 2017 and 2022.



4.2.2. The number of ZEVs on the road sold by five automakers

While ZEVs do not produce any tailpipe emissions, it was necessary to measure the number of SUVs that are ZEVs so that it can be factored into the calculation of ZEVs' impact on CO_2 emissions reduction presented in 4.3.2. Compared to 2017, the number of ZEVs climbed sharply in 2022 for Volkswagen and Hyundai-Kia. Further examination shows that the growth rates for ZEV sedans and ZEV SUVs were different for Hyundai-Kia, while both ZEV sedans and ZEV SUVs increased for Volkswagen. In 2022, Hyundai-Kia's fleet of ZEV SUVs had increased by 3,470 times compared to 2017, while ZEV sedans increased by fourfold during the same period. Volkswagen's fleet of ZEVs increased from zero in 2017 to more than 0.7 million total vehicles in 2022, and its ZEV sedans increased by 16 times over the same period. The increase in ZEV SUVs is a clear sign that Hyundai-Kia and Volkswagen's ZEV sales strategies are focused on SUVs sales.

[FIGURE 13]
The number of ZEVs of five automakers in 2017 and 2022.



4.3
CO_2 emissions from vehicles sold by five automakers

4.3.1. Comparison of tailpipe CO_2 emissions in 2017 and 2022

CO_2 emitted in 2017 and 2022 from vehicles manufactured by the five automakers in this analysis was calculated as follows.

Tailpipe CO_2 emissions from SUVs in 2017:

$$\sum_{n=2008}^{2017} \{(\text{ICE SUVs sold in year n}) \times (\text{average annual } CO_2 \text{ emissions from ICE SUV in year n})\}$$

Tailpipe CO_2 emissions from Sedans in 2017:

$$\sum_{n=2008}^{2017} \{(\text{ICE Sedans sold in year n}) \times (\text{average annual } CO_2 \text{ emissions from ICE Sedan in year n})\}$$

Tailpipe CO_2 emissions from SUVs in 2022:

$$\sum_{n=2013}^{2022} \{(\text{ICE SUVs sold in year n}) \times (\text{average annual } CO_2 \text{ emissions from ICE SUV in year n})\}$$

Tailpipe CO_2 emissions from Sedans in 2022:

$$\sum_{n=2013}^{2022} \{(\text{ICE Sedans sold in year n}) \times (\text{average annual } CO_2 \text{ emissions from ICE Sedan in year n})\}$$

The results of the calculations revealed that tailpipe CO_2 emissions from ICE SUVs sold by Toyota, Volkswagen and Hyundai-Kia in 2022 were relatively similar, ranging from 97.4 to 101.7 tonnes. In terms of sedans, Volkswagen produced the greatest CO_2 emissions with 224.4 tonnes, followed by Toyota and Hyundai-Kia. The volume of CO_2 emissions among the five automakers also aligned with the sales volume.[vi]

The comparison of tailpipe CO_2 emissions in 2017 and 2022 also shows that CO_2 emissions from SUVs increased while CO_2 emissions from sedans decreased for all five automakers. For Toyota, Volkswagen, and Hyundai-Kia, who are the top three automakers in terms of sales, increased tailpipe CO_2 emissions from SUVs outweighed the decrease in tailpipe CO_2 emissions from sedans.

vii Toyota outperformed Volkswagen in total sales volume, but Volkswagen exceeded Toyota in the sale of SUVs and sedans.

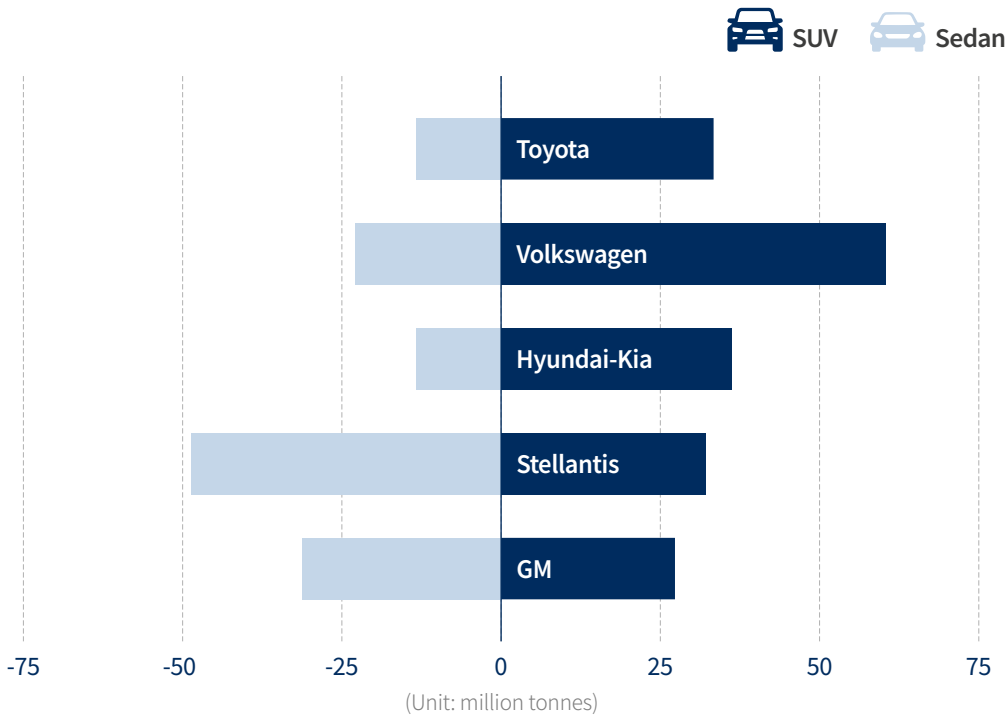
A simple comparison of tailpipe CO_2 emissions from SUVs that wiped out tailpipe CO_2 emissions from sedans in 2017 and 2022 resulted in a net increase of tailpipe CO_2 emissions for Volkswagen (36.8 million tonnes), Hyundai-Kia (21.9 million tonnes) and Toyota (19.7 million tonnes). An increase in tailpipe CO_2 emissions produced by Hyundai-Kia and Volkswagen vehicles in 2022 compared to 2017, a period when ICE vehicle sales began to decline, is particularly noteworthy because it implies that SUVs are the reason for increased CO_2 emissions.

[TABLE 5]
Tailpipe CO_2 emissions from ICE vehicles of five automakers in 2017 and 2022.

(Unit: million tonnes)

Automaker		2017	2022	Rate of change
Toyota	SUV	65.0	98.4	33.4
	Sedan	173.4	159.8	-13.6
Volkswagen	SUV	41.6	101.7	60.1
	Sedan	267.6	244.4	-23.2
Hyundai-Kia	SUV	61.9	97.4	35.5
	Sedan	152.8	139.1	-13.7
Stellantis	SUV	44.4	76.2	31.8
	Sedan	183.5	134.4	-49.1
GM	SUV	44.4	71.4	27.0
	Sedan	136.5	104.3	-32.2

[FIGURE 14]
Change in tailpipe CO_2 emissions from ICE vehicles of five automakers in 2022 compared to 2017.

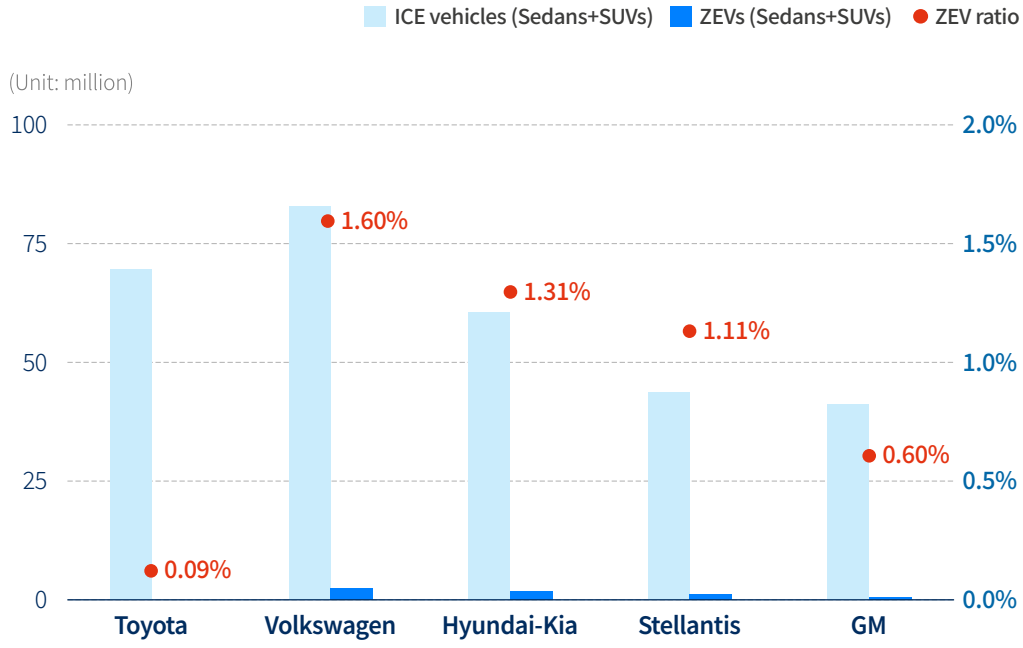


4.3.2. Tailpipe CO_2 emissions and reduction impact from ZEVs

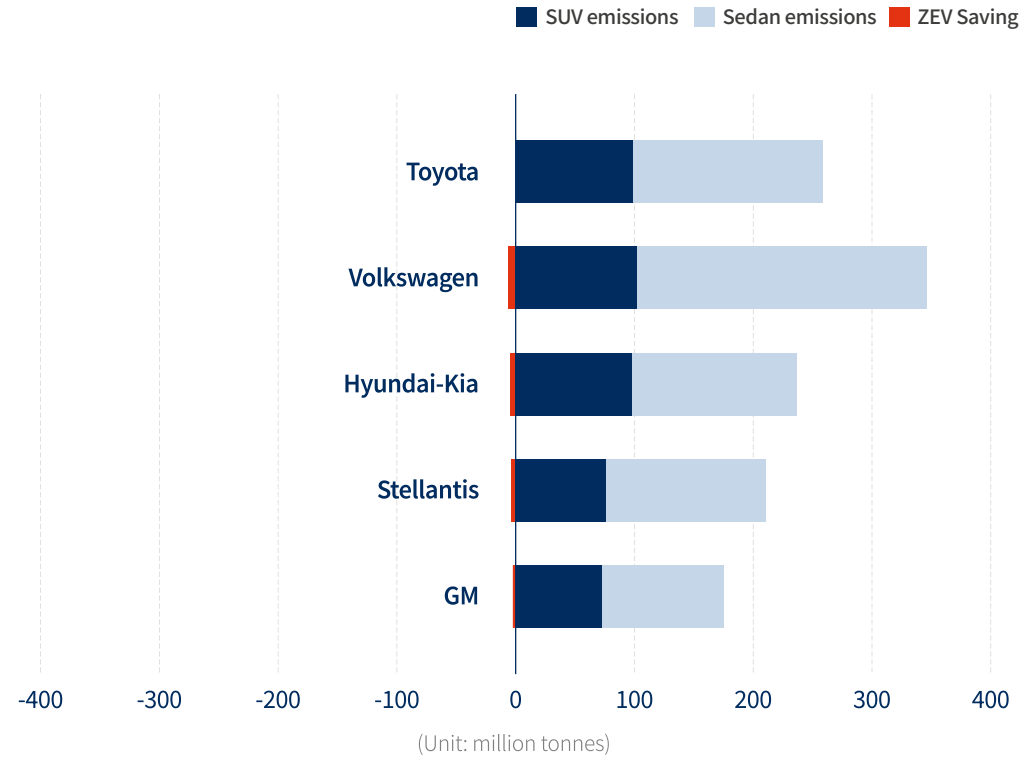
In this section, the volume of CO_2 emissions avoided by the transition to ZEVs is compared to the volume of emissions from SUVs on the road from the five manufacturers in 2022. Using the same methodology as in Section 4.2, the number of vehicles on the road in 2022 was determined by adding the number of ICE vehicles sold by each manufacturer between 2013 and 2022 (sedans and SUVs) and the number of ZEVs. As shown in Figure 15, in 2022 ICE vehicles overwhelmingly outnumbered ZEVs for each manufacturer. In 2022, Volkswagen had the highest percentage of ZEVs on the road at 1.6%, and Toyota the lowest at 0.09%.

After calculating the number of vehicles, tailpipe CO_2 emissions in 2022 were calculated by multiplying the number of vehicles by the average CO_2 emissions of the year. The formula used was presented in section 4.3.1. The difference made by calculating the absence of ZEVs was the impact ZEVs have on the reduction of CO_2 emissions. As presented in Figure 15, Volkswagen has the highest number of ICE vehicles and also produced the highest tailpipe CO_2 emissions, with 346.1 million tonnes. Measuring the impact of ZEVs on reducing the tailpipe CO_2 emissions for Volkswagen generated 5.6 million tonnes of tailpipe CO_2. Meanwhile, ICE vehicles made by Toyota produced 258.2 million tonnes of tailpipe CO_2 emissions. Toyota has the lowest share of ZEVs in its fleet, which reduced its CO_2 emissions by 0.22 million tonnes. While Hyundai-Kia was second behind Volkswagen in terms of the number of ZEVs, the impact of ZEVs on CO_2 emissions reduction was also relatively marginal with just 3.2 million tonnes, which was just 1/75 of tailpipe CO_2 emissions produced by its entire fleet of ICE vehicles. Over the past decade, SUV sales have steadily increased. CO_2 road emissions from SUVs from the top three manufacturers totaled 298 million tonnes in 2022: 101.7 million tonnes from Volkswagen, 98.4 million tonnes from Toyota, and 97.4 million tonnes from Hyundai-Kia. The total sum of SUV road emissions of the three manufacturers in 2022 was 33 times the 9 million tonnes of road emissions reduced by ZEVs from Volkswagen, Toyota, and Hyundai the same year.

[FIGURE 15]
The number of vehicles on the road by five automakers in 2022.



[FIGURE 16]
Tailpipe CO_2 emissions from ICE vehicles and reduction impacts from ZEV sales in 2022.



5.

Conclusion

5.
Conclusion

This report was compiled to understand how the business strategies of five industry-leading automakers are adversely impacting the environment and climate crisis and present steps to offset any damage. The automakers featured in this analysis posted the highest sales volume globally in 2022: Toyota, Volkswagen, Hyundai Motor Group (Hyundai-Kia), Stellantis and General Motors (GM). In order to validate the gravity of the situation objectively, the analysis of CO_2 emissions by vehicles sold by the five automakers that are being operated on the road was based on data released by MarkLines and the United States Environmental Protection Agency (EPA). Data for the 15 years from 2008 to 2022 was reviewed to ascertain trends over time.

Analysis reveals that the five automakers continue to heavily depend on internal combustion engine (ICE) vehicles, making them major sources of CO_2 emissions. While the sales of zero-emission vehicles (ZEV) has been increasing in recent years, the prominence of this class of vehicle in the market remains marginal. Greenpeace asserts that automakers should be tasked to pursue aggressive transitions by taking urgent steps, including complete phasing-out of ICE vehicles and offering sustainable mobility solutions.

SUVs that have become the main market of automakers are also revealed to be contributing to climate change because the CO_2 emissions produced during the entire lifespan of SUVs from manufacturing to operation on the road greatly exceeds the CO_2 emissions produced by passenger sedans. Undeterred by this fact, however, most of the five automakers subject to the analysis are pursuing strategies to expand the SUV market. As the sale of SUVs increased by 154.7% industry-wide from 2013 to 2022, the five automakers combined expanded their SUV fleet at a rate of 42% when comparing 2013 and 2022, which is an increase of 2.8 times. Among the five automakers, Hyundai-Kia established the greatest share of SUVs in its entire fleet, with more than half (52.7%) of its sales in 2022. Unlike the ICE vehicle market that has begun to scale back, it is evident that major automakers are intent on pursuing the SUV market. The increased number of SUVs in the ZEV category is also evident. Only 17.8% of ZEVs sold by the five automakers were SUVs in 2018, but the number soared to 62.8% in 2022. It's true that ZEVs do not produce tailpipe emissions, but ZEV SUVs are still responsible for a greater carbon footprint than ZEV sedans because they share many downfalls of ICE SUVs such as consuming more steel during manufacturing.

5. Conclusion

This report clearly demonstrates the devastating impact of the increased number of SUVs on the road on the climate crisis. Tailpipe CO_2 emissions are the most significant component of CO_2 emissions produced during the lifetime of a vehicle and are responsible for 70 to 80% of the total emissions. Analysis of CO_2 emissions produced by ICE vehicles verifies that SUVs produce an average of 23.2g more CO_2 emissions than sedans per kilometer. When the parameter is narrowed to ICE vehicles made by Volkswagen and Hyundai-Kia, the increased CO_2 emissions by SUVs jump to more than 40 grams per kilometer. In one year, the amount of increased CO_2 emitted by one SUV produced by Volkswagen and one by Hyundai-Kia compared to a sedan is calculated to be almost 8 tonnes.

Our findings are corroborated by the fact that emissions by SUVs increased, yet the emissions by sedans decreased for all five automakers when comparing tailpipe CO_2 emissions based on sales volumes in 2017 and 2022. CO_2 emissions by SUVs increased at a rate so steep that it propelled the overall increase of CO_2 emissions for Toyota, Volkswagen and Hyundai-Kia by not only canceling out but also exceeding the CO_2 emissions reduced as a result of ICE vehicle sales decline.

Growth of the ZEV market does lead to a reduction of CO_2 emissions, but the impact remains negligible because the market share is marginal. The amount of CO_2 emissions by ZEVs decreased to just 1/75 of CO_2 emitted by ICE vehicles for Hyundai-Kia. The ratio plummeted to 1/1,174 for Toyota, because Toyota reported the lowest ZEV sales.

6.

Recommendations for auto industry decarbonization

6.
Recommendations for the auto industry to achieve decarbonization

The auto industry is in a powerful position to be able to decarbonize the industry effectively. A first step would be to release the complete data on CO_2 emissions produced by an SUV throughout its lifespan with full transparency. At the same time, automakers must also present smaller, lighter and more energy-efficient models of transportation powered by 100% renewable energy. Eventually, automakers must choose to move away from selling vehicles towards offering an entirely new range of mobility solutions.

1.
Accelerating the phase-out of ICE vehicles

Industry-leading automakers must steer the market in the right direction by taking aggressive and unwavering actions to phase out ICE vehicles. This report urges Toyota, Volkswagen, Hyundai-Kia, Stellantis and GM to stop the sale of ICEs by 2030, with 2028 as the more aggressive target year for Europe. In addition, phasing out the ICE technology in the auto industry must incorporate discourse on just transition to ensure rights of workers made vulnerable by the transition.

2.
Reducing CO_2 emissions by downsizing the SUV market

Automakers must concede that their drive to maximize profits by expanding the SUV market negates any attempt to reduce the CO_2 emissions such as expanding the EV market. As presented in this report, the growth of the SUV market resulted in not only a significant increase in direct emissions but also the industry-wide carbon footprint by increased steel consumption. Since the growth of the EV market remains insufficient to offset such rapid increase, it is necessary for automakers to scale down SUV production.

3.
Investment and use of carbon-neutral steel

In the region of 50–65% of an average car's weight is steel. GHG emitted during the production of steel for auto manufacturing is a key source of the carbon footprint left by an automobile. McKinsey & Company, a consulting firm, estimated that emissions from material production for automobiles may reach 60% of lifecycle emissions by 2040.[15] Automakers must contribute to the decarbonization of steel by implementing actions such as measuring and releasing data on carbon footprint from material production, purchasing low-carbon steel, setting goals for CO_2 emissions reduction from steel production, scaling back SUV production and advancing technology for decarbonized steel.

4.
Support changes in travel and reduce private car ownership

Any effort to achieve meaningful reduction of GHG emissions to tackle the climate crisis must be accompanied by rapidly working towards a global transition from ICE vehicles to EVs and reducing the number of cars on the road. This can be accomplished by reducing private ownership of cars, improving public transportation systems, expanding car-sharing options and executing urban development that prioritizes active travel such as walking and bicycle use. Automakers must spearhead and take part in the transition by re-envisioning its conventional business model that revolves around manufacturing and selling automobiles.

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Appendix A.
Vehicle Classification

Toyota	Daihatsu Lexus Toyota
Volkswagen	Audi Bentley Lamborghini Porsche SEAT Skoda Volkswagen Bugatti Cupra Jetta
Hyundai Motor Group	Genesis Hyundai Kia
Stellantis	Alfa Romeo Chrysler Citroën DS Fiat Jeep Lancia Maserati Opel Peugeot Vauxhall Abarth Dodge
General Motors Group	BrightDrop Buick Cadillac Chevrolet GMC

Appendix B.
CO_2 Emissions Per Distance by Vehicle Type of 5 Automakers

(unit: g/km)

Automaker	Vehicle Type	2008	2009	2010	2011	2012	2013	2014	2015
Toyota	SUV	248.27	239.63	236.21	234.85	235.55	227.65	220.02	223.29
	Sedan	196.81	195.09	181.72	195.42	177.54	178.21	178.83	177.15
Volkswagen	SUV	230.91	230.91	230.91	230.91	230.91	235.41	240.89	241.67
	Sedan	240.31	229.23	218.89	211.13	210.78	210.09	205.70	199.49
Hyundai-Kia	SUV	270.86	265.74	238.13	229.79	231.67	230.79	243.97	240.67
	Sedan	208.97	204.65	196.50	196.53	191.12	188.25	194.17	195.62
Stellantis	SUV	254.95	254.95	250.95	252.15	252.15	235.79	224.77	219.28
	Sedan	249.47	251.64	249.03	244.06	231.25	226.54	237.46	217.53
GM	SUV	272.21	266.91	235.85	234.25	241.41	227.60	227.93	222.70
	Sedan	240.34	230.38	231.22	231.18	214.18	211.27	206.61	205.92

Automaker	Vehicle Type	2016	2017	2018	2019	2020	2021	2022
Toyota	SUV	214.76	213.87	209.39	196.35	195.50	192.68	186.75
	Sedan	177.83	172.65	165.82	166.01	158.50	159.44	160.50
Volkswagen	SUV	242.87	245.34	232.94	232.94	269.56	258.03	191.27
	Sedan	196.39	192.59	203.13	183.90	191.86	196.34	195.76
Hyundai-Kia	SUV	226.33	221.01	217.12	212.67	211.47	201.02	199.67
	Sedan	186.07	173.38	176.95	172.61	164.95	163.26	167.59
Stellantis	SUV	221.04	219.67	210.54	209.38	208.45	211.20	211.62
	Sedan	231.55	239.67	247.65	248.98	254.64	258.91	249.40
GM	SUV	220.69	212.04	191.41	195.21	195.74	190.12	191.28
	Sedan	201.29	187.04	187.31	205.43	191.80	199.00	197.71

Appendix C.
CO_2 Emissions Per Year (20,000km) by Vehicle Type of 5 Automakers

(unit: tonne)

Automaker	Vehicle Type	2008	2009	2010	2011	2012	2013	2014	2015
Toyota	SUV	4965474	4792657	4724116	4696970	4711009	4553077	4400487	4465742
	Sedan	3936294	3901860	3634372	3908310	3550806	3564153	3576671	3543051
Volkswagen	SUV	4618131	4618131	4618131	4618131	4618131	4708174	4817757	4833373
	Sedan	4806143	4584677	4377860	4222637	4215605	4201755	4114038	3989756
Hyundai-Kia	SUV	5417277	5314795	4762520	4595782	4633329	4615767	4879414	4813448
	Sedan	4179334	4092951	3930003	3930678	3822301	3765022	3883377	3912308
Stellantis	SUV	5098957	5098957	5019006	5042976	5042976	4715860	4495398	4385627
	Sedan	4989405	5032758	4980602	4881156	4624967	4530706	4749234	4350647
GM	SUV	5444156	5338287	4717080	4685033	4828176	4552053	4558544	4454061
	Sedan	4806727	4607535	4624359	4623573	4283688	4225383	4132107	4118338

Automaker	Vehicle Type	2016	2017	2018	2019	2020	2021	2022
Toyota	SUV	4295221	4277419	4187874	3926970	3910001	3853605	3735038
	Sedan	3556548	3452916	3316405	3320172	3169900	3188722	3209976
Volkswagen	SUV	4857489	4906780	4658864	4658864	5391257	5160650	3825472
	Sedan	3927855	3851722	4062630	3677921	3837147	3926858	3915191
Hyundai-Kia	SUV	4526540	4420265	4342399	4253364	4229356	4020336	3993450
	Sedan	3721364	3467599	3539016	3452109	3299097	3265197	3351757
Stellantis	SUV	4420890	4393374	4210720	4187657	4169069	4223974	4232489
	Sedan	4630910	4793407	4953097	4979558	5092863	5178264	4988019
GM	SUV	4413749	4240788	3828216	3904126	3914818	3802479	3825517
	Sedan	4025862	3740708	3746268	4108657	3835961	3980073	3954268

Appendix D.
CO_2 Emissions Per Decade (200,000km) by Vehicle Type of 5 Automakers

(unit: tonne)

Automaker	Vehicle Type	2008	2009	2010	2011	2012	2013	2014	2015
Toyota	SUV	49654744	47926575	47241161	46969701	47110093	45530767	44004874	44657417
	Sedan	39362944	39018595	36343722	39083096	35508064	35641528	35766709	35430508
Volkswagen	SUV	46181307	46181307	46181307	46181307	46181307	47081739	48177570	48333733
	Sedan	48061431	45846769	43778596	42226372	42156049	42017554	41140379	39897560
Hyundai-Kia	SUV	54172771	53147947	47625199	45957816	46333286	46157666	48794135	48134476
	Sedan	41793343	40929514	39300032	39306775	38223009	37650218	38833771	39123084
Stellantis	SUV	50989572	50989572	50190057	50429756	50429756	47158600	44953981	43856269
	Sedan	49894051	50327579	49806019	48811563	46249665	45307061	47492337	43506474
GM	SUV	54441557	53382869	47170795	46850326	48281764	45520533	45585436	44540610
	Sedan	48067267	46075350	46243587	46235733	42836877	42253826	41321071	41183376

Automaker	Vehicle Type	2016	2017	2018	2019	2020	2021	2022
Toyota	SUV	42952206	42774186	41878740	39269696	39100009	38536046	37350383
	Sedan	35565481	34529157	33164052	33201722	31699001	31887221	32099761
Volkswagen	SUV	48574892	49067799	46588640	46588640	53912573	51606495	38254716
	Sedan	39278547	38517223	40626303	36779214	38371468	39268581	39151912
Hyundai-Kia	SUV	45265404	44202650	43423989	42533636	42293560	40203357	39934503
	Sedan	37213636	34675994	35390161	34521087	32990968	32651971	33517566
Stellantis	SUV	44208903	43933743	42107199	41876567	41690686	42239743	42324888
	Sedan	46309101	47934072	49530967	49795578	50928632	51782643	49880187
GM	SUV	44137494	42407875	38282160	39041259	39148175	38024785	38255168
	Sedan	40258620	37407084	37462680	41086567	38359605	39800730	39542681

GREENPEACE

Greenpeace East Asia
6F Cheongryong bldg 257, Hangang-daero, Yongsan-gu,
Seoul (04322), South Korea

Tel. +82 2 3144 1994
Fax. +82 2 6455 1995
Inquiry. press.kr@greenpeace.org
www.greenpeace.org/korea

Authors
Donghun Kang Jisu Woo
Hyewon Heather Choi Eunseo Erin Choi Hyeran Hong