Two-wheelers in Vietnam: A baseline analysis of fleet characteristics and fuel consumption in 2019 and 2020

Author: Dinh-Son Tran, Huong Le, Zifei Yang
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Introduction

In 2018, there were more than 58 million registered motorcycles and mopeds in Vietnam. The two-wheeler ownership rate was approximately 615 vehicles per 1000 inhabitants[1] compared to a car ownership rate of 38 vehicles per 1000 inhabitants.[2] Two-wheelers including motorcycles and mopeds are dominant transport modes that play an essential role in serving the country's travel demand. Two-wheelers are also major contributors to air pollution in the country; they are the largest source of emissions among transport modes, accounting for more than 90% of carbon monoxide (CO) and volatile organic compounds (VOC), and 60% of suspended particles.[3]

Vietnam aims to reduce GHG emissions and air pollution. In September 2020, Vietnam submitted its updated NDC (Nationally Determined Contribution) to the UNFCCC, which set a goal of reducing GHG emissions by 9% (using domestic resources only) and by 27% (with international support) by 2030 compared to the baseline year of 2014. Transport is responsible for 18% of Vietnam's total national GHG emissions.[4] Based on the country's NDC, transport is subsumed under the energy sector, which aims to reduce GHG by 5.5% (domestic resources) and 16.7% (with international supports) compared to 2014. To reduce GHG emissions and air pollution from the transport sector, measures to reduce two-wheeler emissions are essential.

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1   Minh Duc. (2019). Xe máy tại Việt Nam tăng 48 lần trong gần 30 năm (in Vietnamese) https://vtv.vn/trong-nuoc/xe-may-tai-viet-nam-tang-48-lan-trong-gan-30-nam-2019041715472122.htm (In Vietnamse)
2   Vietnam Register. (2021) (in Vietnamese) http://www.vr.org.vn/thong-ke/Pages/tong-hop-so-lieu-phuong-tien-giao-thong-trong-ca-nuoc.aspx
3   MONRE. (2018). Báo Cáo Môi Trường Quốc Gia 2017 - Chuyên Đề: Quản Lý Chất Thải. Ha Noi, Viet Nam. (In Vietnamese)
4   Oh, J. E., Cordeiro, M., Rogers, J. A., Nguyen, K., Bongardt, D., Dang, L. T., & Tuan, V. A. (2019). Addressing Climate Change in Transport-Volume 1: Pathway to Low-Carbon Transport.

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This paper aims to develop a baseline of fuel consumption of the two-wheeler fleet in Vietnam as a foundation for future policies designed to reduce emissions from two-wheelers and to set fuel economy standards. Policies to reduce emissions from two-wheelers could help Vietnam meet its climate and air pollution reduction goals. For the analysis, we developed a database of the two-wheeler fleet sold in 2019 and 2020. We then analyze vehicle characteristics and fuel consumption by two-wheeler type and by manufacturer. Given the similarity of fleet characteristics of the 2019 and 2020 fleet, the report focuses on data for the 2020 fleet but also identifies important changes from 2019 to 2020. We also analyze the characteristics and key manufacturers of electric two-wheelers sold in 2020.

This paper first provides an overview of two-wheeler market sales and general information regarding fleet characteristics. Second, we present an analysis of two-wheelers sold in 2020, focusing primarily on vehicle types and manufacturers. Next, we describe the fuel consumption of the two-wheeler fleet by features and by manufacturers. Then, we present an analysis of electric two-wheelers (E2W), and finally, we summarize the key findings of this paper.

Definitions and data sources

In Vietnam, two-wheelers commonly refer to bicycles, motorcycles, and mopeds. In this paper, we focus only on two-wheeler motorcycles and mopeds. Bicycles are not registered vehicles, and as an environmentally friendly transport mode, do not require analysis in this paper, which focuses on pollution from transport. Meanwhile, the number of three-wheelers is very small, and their use is strongly restricted. Therefore, bicycles and three-wheelers are not included in the scope of this paper.

Definitions of motorcycles and mopeds are given in the *National technical regulation on safety and environmental protection for motorcycles and mopeds* issued by the Ministry of Transport (MOT) (QCVN 14:2015/BGTVT).[5] *Motorcycles* are vehicles with two wheels, an engine displacement of 50 cm³ or higher, a maximum speed of more than 50 km/h, and curb weight not exceeding 400 kg. *Mopeds* are vehicles with two wheels whose maximum speed does not exceed 50 km/h and whose engine displacement is not more than 50 cm³ for the internal combustion engine (ICE) and whose motor power, in the case of electric models, is not more than 4 kW. The same definition of electric mopeds is also given in Decree No. 100/2019/ND-CP.[6] However, regarding electric two-wheelers (E2W) with motor power of more than 4 kW and maximum speed higher than 50 km/h, there is no clear definition for this type of vehicle in existing regulations and standards. In this paper, this type of vehicle will be defined as an electric motorcycle.

The classification of two-wheelers is presented in Table 1. Mopeds are divided into internal combustion mopeds (mopeds) and electric mopeds (e-mopeds). Motorcycles are classified into electric motorcycles (e-motorcycles), ICE motorcycles with manual transmission (mostly underbones), and ICE motorcycles with automatic transmission (mostly scooters). In this paper, ICE two-wheelers and E2W will be called two-wheelers. Internal combustion mopeds and motorcycles will be referred to as mopeds and motorcycles.

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5   Vietnam Ministry of Transport. (2015). QCVN 14:2015/BGTVT: National technical regulation on safety and environmental protection for motorcycles and mopeds

6   Vietnamese Government. (2019). Decree No 100/2019/NĐ-CP: Decree administration penalties for road traffic offences and rail transport offences

Table 1. Classification of two-wheeler vehicles

Class	Vehicle types	Engine displacement (cc)/ Motor power (kW)	Maximum speed (km/h)	Transmission
Moped	**Moped**	≤ 50	≤ 50	-
	E-moped	≤ 4	≤ 50	-
Motorcycle	**Motorcycle (M)**[*]	> 50	> 50	Manual
	Motorcycle (A)[**]	> 50	> 50	Automatic
	E-motorcycle	> 4	> 50	-

Note: * motorcycles with manual transmission, ** motorcycles with automatic transmission

In 2020, more than 300 two-wheeler vehicle models were sold. The top 50 models from 12 manufacturers constitute 97.6% of total sales, representing the new two-wheeler fleet in the country in 2020. Therefore, these top 50 models' key characteristics are selected for detailed analysis, including engine displacement, engine power, curb weight, power transmission technology, fuel type, and fuel consumption. Data on these parameters are fully available, except the data for curb weight, which was 98% available. Of the 50 models, 27 were ICE two-wheeler models (2 moped models and 25 motorcycle models), and 23 were E2W models (18 e-moped models and 5 e-motorcycle models). In this paper, when we refer to the fleet, we mean the top 50 models that represent 97.6% of total 2020 sales.

The two-wheeler vehicle database was compiled from a variety of sources, including:
  » Motorcycle Data (www.motorcyclesdata.com/)
  » Vietnam Register website (www.vr.org.vn/)
  » Public websites of manufacturers (e.g., www.honda.com.vn/)
  » Showroom information (e.g., thegioixedien.com.vn, desk reviewing)

Overview of two-wheeler market sales and characteristics

Annual sales of two-wheelers from 2016 to 2020 are shown in Figure 1. The sales of two-wheelers increased rapidly from 2016 to 2017 and reached a peak in 2018 with 3.6 million vehicles. Sales in 2020 fell by 13.6% compared to 2019 due to the COVID-19 pandemic.
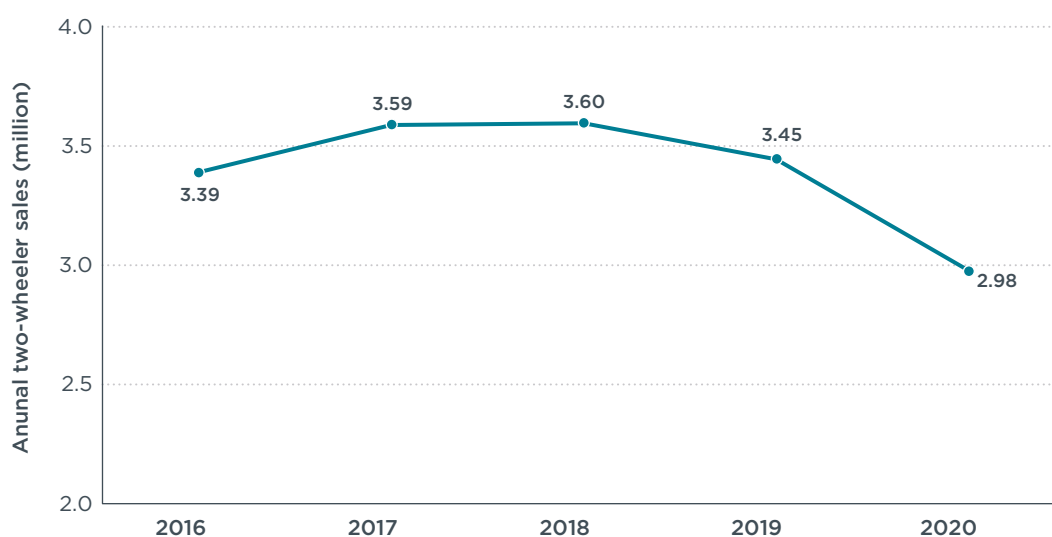

**Figure 1.** Annual sales of two-wheelers in Vietnam, 2016-2020

Table 2 gives the two-wheeler market share by vehicle type in 2019 and 2020. ICE motorcycles accounted for the majority of the two-wheeler fleet with 94.8% market share in 2019 and 91% in 2020. Manual and automatic transmissions are approximately evenly distributed. E-motorcycles account for a small market share (1.1% in 2019 and 1.2% in 2020). Mopeds had a smaller market share than motorcycles and most mopeds sold were e-mopeds. The e-moped market share increased significantly between 2019 and 2020. In total, the market share of E2Ws increased from 4.9% in 2019 to 8.3% in 2020 mainly due to a rapid increase in the sales share of e-mopeds.

All ICE mopeds were manual transmission vehicles. The data also shows that all ICE two-wheelers were powered by gasoline.

Table 2. Market share of two-wheelers in 2019 and 2020

| Class	Vehicle type	2019		2020	
		Sales	Market share	Sales	Market share
Moped	Moped	8,938	0.3%	21,839	0.7%
	E-moped	127,308	3.8%	206,075	7.1%
	Total	136,246	4.1%	227,914	7.8%
Motorcycle	Motorcycle (M)	1,516,687	45.4%	1,309,280	45.1%
	Motorcycle (A)	1,648,358	49.4%	1,332,036	45.9%
	E-motorcycle	36,120	1.1%	34,450	1.2%
	Total	3,201,165	95.9%	2,675,766	92.2%
Total		3,337,411	100%	2,903,680	100%

Key features of the new two-wheeler fleet in 2020 are presented in Figure 2. Figure 2a shows that ICE motorcycles dominate the 2020 fleet, with 91%, and that E2Ws including e-mopeds and e-motorcycles account for 8.3% of the fleet. Figure 2b presents the distribution of engine displacement: 66.5% of two-wheelers have engine displacement between 100 cc and 125 cc, followed by vehicles with engine displacement between 50 and 100 cc (14.2%), and between 125 cc and 150 cc (8%). Regarding curb weight (Figure 2c), vehicles weighing between 100 kg and 125 kg, and those lighter than 100 kg, have the highest share in the fleet, accounting for 54.1% and 40.8%, respectively. ICE two-wheelers with engine power between 6 kW and 8 kW account for the highest market share, 61.6%, followed by two-wheelers with engine power from 8 kW to 10 kW, whose market share is 18.3% (Figure 2d).

(a) Vehicle type

(b) Engine displacement

(c) Curb weight

(d) Engine/Motor power
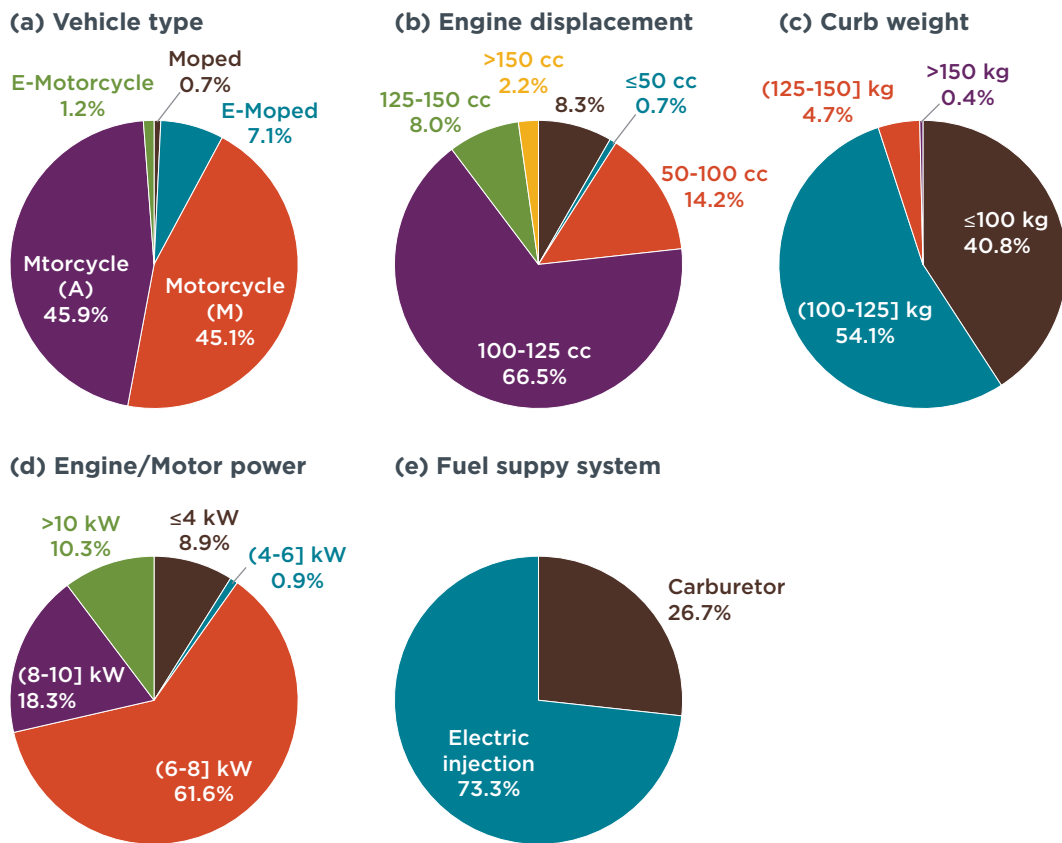
(e) Fuel suppy system

Figure 2. Key parameters of the new two-wheeler fleet sold in 2020

Figure 2e presents the two-wheeler market segmented by fuel supply system. The fuel injection system is widely used for two-wheelers in Vietnam. Among 27 ICE two-wheeler models, 21 use fuel injection, while 6 use carburetors. In total, 73.3% of two-wheelers sold in 2020 used fuel injection technology, and 26.7% used carburetor technology.

The distribution of transmission technologies of the two-wheeler fleet sold in 2020 is described in Figure 3. In this paper, two-wheelers with automatic transmission (also known as continuous variable transmission—CVT) make up 45.9% of the fleet. Vehicles with manual transmission account for 45.8% of the fleet, 82.6% of which featured four gears and 17.4% six gears.
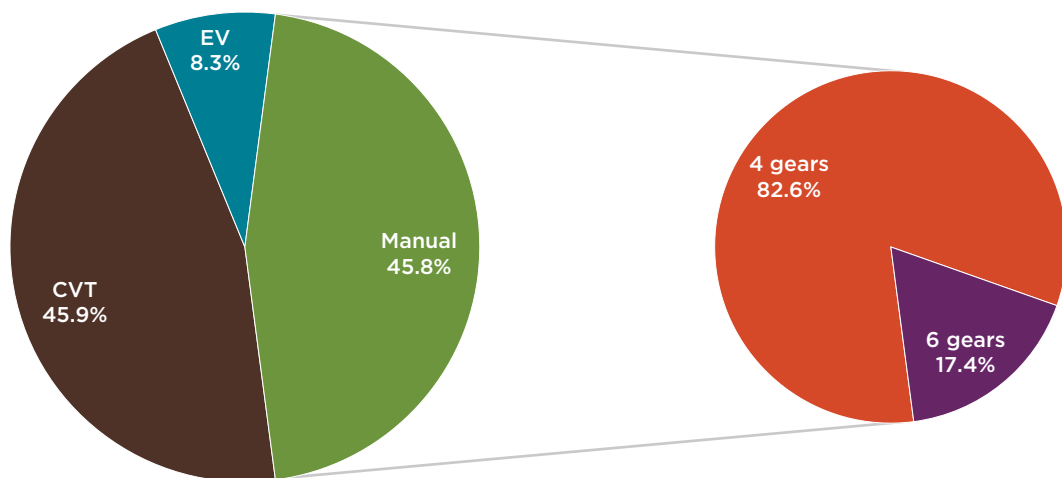
Figure 3. Transmission technology of new two-wheeler fleet sold in 2020

Summary of top-selling models

The top 10 best-selling two-wheeler models account for 76.5% of the market. Key parameters of these top-selling models are described in Table 3. All were ICE motorcycles, including 6 models with manual transmission and 4 with automatic transmission. Honda accounted for 8 of the 10 models, including the top 3 best-sellers. The Vision was the best-selling CVT ICE motorcycle (scooter), and the Wave Alpha 110 was the best-selling ICE motorcycle with the manual transmission (underbone); both are from Honda. Images of these two models are presented in Figure 4. Two of the top-selling models, Honda Wave Alpha 110 and Yamaha Sirius are equipped with carbureted engine. The data related to fuel consumption of the top 10 best-selling models in Table 3 was collected from manufacturers' websites. Fuel consumptions of these models vary greatly, from 1.54 l/100 km (Future from Honda) to 2.16 l/100 km (SH Mode also from Honda). Starting January 1st 2020, two-wheeler manufacturers in Vietnam were required to display the fuel consumption labels (certified by Vietnam Register) on newly manufactured, assembled, and imported motorcycles and mopeds. We also estimated the CO2 emissions (g/km) for these models. The fuel CO_2 content factor (for gasoline) was 2408 g/l based on the estimation of Energy Conservation Research and Development Center (ENERTEAM).[7]

Table 3. Top 10 best-selling two-wheeler models in 2020

	Brand	Model	Market share	Engine size (cc)	Weight (kg)	Power (kW)	Transmission type, gear count	FC (l/100 km)	CO_2 emissions (g/km)
1	Honda	Vision	17.2%	110	102	6.6	CVT	1.88	45.27
2	Honda	Wave Alpha 110	13.7%	97*	97	6.1	Manual, 4	1.90	45.75
3	Honda	Air Blade 125	9.6%	124	111	8.4	CVT	1.99	47.92
4	Yamaha	Sirius (R/RC/RL)	6.9%	115*	96	6.4	Manual, 4	1.99	47.92
5	Honda	SH Mode	6.0%	124	116	8.2	CVT	2.16	52.01
6	Honda	LEAD 125	5.7%	124	113	7.9	CVT	2.02	48.64
7	Honda	Future Fi	5.0%	125	104	6.8	Manual, 4	1.54	37.08
8	Honda	WAVE RSX Fi 110	5.0%	109	99	6.5	Manual, 4	1.70	40.94
9	Honda	Winner X	4.0%	149	123	11.5	Manual, 6	1.70	40.94
10	Yamaha	Exciter	3.3%	150	121	13.3	Manual, 6	2.09	50.33

* Vehicle with carbureted engine.

(a) Honda Vision

(b) Honda Wave Alpha 110

Figure 4. Best-selling two-wheeler models in Vietnam in 2020

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7   ENERTEAM. (2021). Cách quy đổi các dạng năng lượng sang TOE như thế nào?. http://enerteam.org/quy-doi-nang-luong-sang-toe.html (in Vietnamese)

Two-wheeler characteristics by vehicle type

The key features of two-wheeler types sold in 2020 are presented in Table 4. ICE mopeds have the lowest engine displacement, curb weight, engine power, and fuel consumption among the two-wheelers. The averages of these parameters were calculated for ICE two-wheelers and for the entire 2020 fleet (ICE two-wheelers and E2Ws). The vehicle characteristics are similar for motorcycles with manual and automatic transmission. Motorcycles with automatic transmission on average have slightly higher engine displacement, curb weight, engine power, and fuel consumption. The fleet average fuel consumption in this paper refers to the average fuel consumption of the whole 2020 fleet (including ICE two-wheelers and E2Ws). The average fuel consumption of ICE two-wheelers was 1.92 l/100 km, and the fleet average fuel consumption after incorporating E2Ws (whose fuel consumption in our calculation is zero) falls by 8.3% to 1.76 l/100 km.

Table 4. Average values for key parameters of two-wheelers by vehicle type, 2020

Parameters		Fleet (top 50 models)	Moped	E-moped	Motorcycle (M)	Motorcycle (A)	E-motorcycle
Market share (%)		100% (*)	0.7%	7.1%	45.1%	45.9%	1.2%
Engine displacement (cc)	Min (ICE)	49	49	—	97	108	—
	Max (ICE)	155	49	—	150	155	—
	Avg (ICE)	117.2	49	—	115	120	—
	Avg (incl. E2W)	107.6	—	—	—	—	—
Curb weight (kg)	Min	80	97	90	96	99	80
	Max	155	98	122	123	134	155
	Avg (ICE)	105.5	97.7	92.5	102.4	110.4	114.3
	Avg (incl. E2W)	106.3	—	—	—	—	—
Engine power (kW)	Min	0.5	2	0.5	5.3	6	1.5
	Max	13.6	2	2.4	13.6	12.4	4
	Avg (ICE)	7.6	2	1.1	7.4	7.8	2.4
	Avg (incl. E2W)	7.1	—	—	—	—	—
Fuel consumption (l/100km)	Min (ICE)	1.54	1.54	—	1.54	1.69	-
	Max	2.51	2.51	—	2.51	2.46	-
	Avg (ICE)	1.92	1.28	—	1.83	2.01	-
	Avg (incl. E2W)	1.76	—	—	—	—	—

Note: "—"not applicable; (*) representing 97.6% of the two-wheeler fleet sold in 2020

Figure 5 further illustrates the vehicle characteristics by vehicle type of the 2020 fleet. Characteristics of the 2019 fleet were very similar to the 2020 fleet. ICE motorcycles had a wider range of engine size and engine power. Motorcycles with automatic transmissions had the largest engine size and engine power, followed by motorcycles with manual transmissions. Regarding curb weight, e-motorcycles were heaviest, at an average 114.3 kg and a maximum weight of 155 kg. Two-wheelers with a curb weight of less than 125 kg were the most common in the fleet. All mopeds (incl. e-mopeds) and e-motorcycles have motor power of less than 4 kW, which is much lower than the average values of the fleet (at 7 kW). All ICE mopeds are four-gear vehicles, compared to 82.6% of ICE motorcycles. In terms of fuel supply technology, all ICE mopeds have a carburetor, 52.7% of ICE motorcycles (M) have a carburetor, and 47.3% are equipped with electronic fuel injection systems. All motorcycles with automatic transmissions are equipped with fuel injection technology.
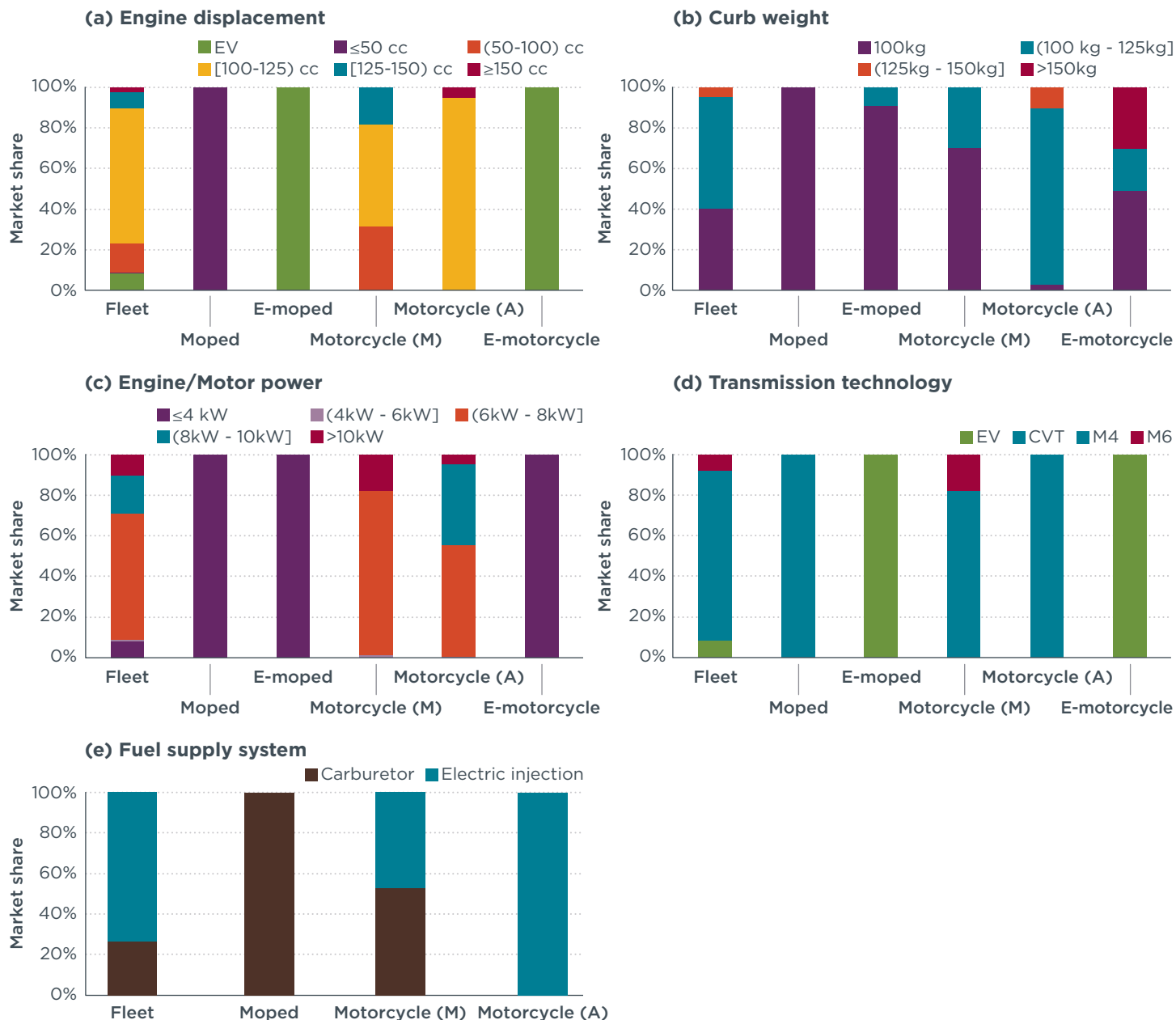
Figure 5. Key parameters of two-wheelers by vehicle type, 2020

Two-wheeler characteristics by manufacturer

Figure 6 gives an overview of new two-wheeler market shares in 2020, by manufacturer. The top 50 two-wheeler models come from twelve manufacturers. Most of the manufacturers produced only ICE two-wheelers or only electric two-wheelers, except for SYM (which offered both ICE two-wheelers and E2Ws). Five of the twelve are ICE two-wheeler manufacturers. Other manufacturers produce only E2Ws. Honda dominates the market with a share of 73.4%, followed by Yamaha with 15.9%. The remaining manufacturers have only 10.7% of the two-wheeler market share in 2020. Although Honda and Yamaha had the largest two-wheeler market share among manufacturers, they only sell ICE two-wheelers in Vietnam.

In this section, we focus only on the manufacturers of ICE two-wheelers and the characteristics of their fleets. The manufacturers and characteristics of E2Ws are discussed in the following section.
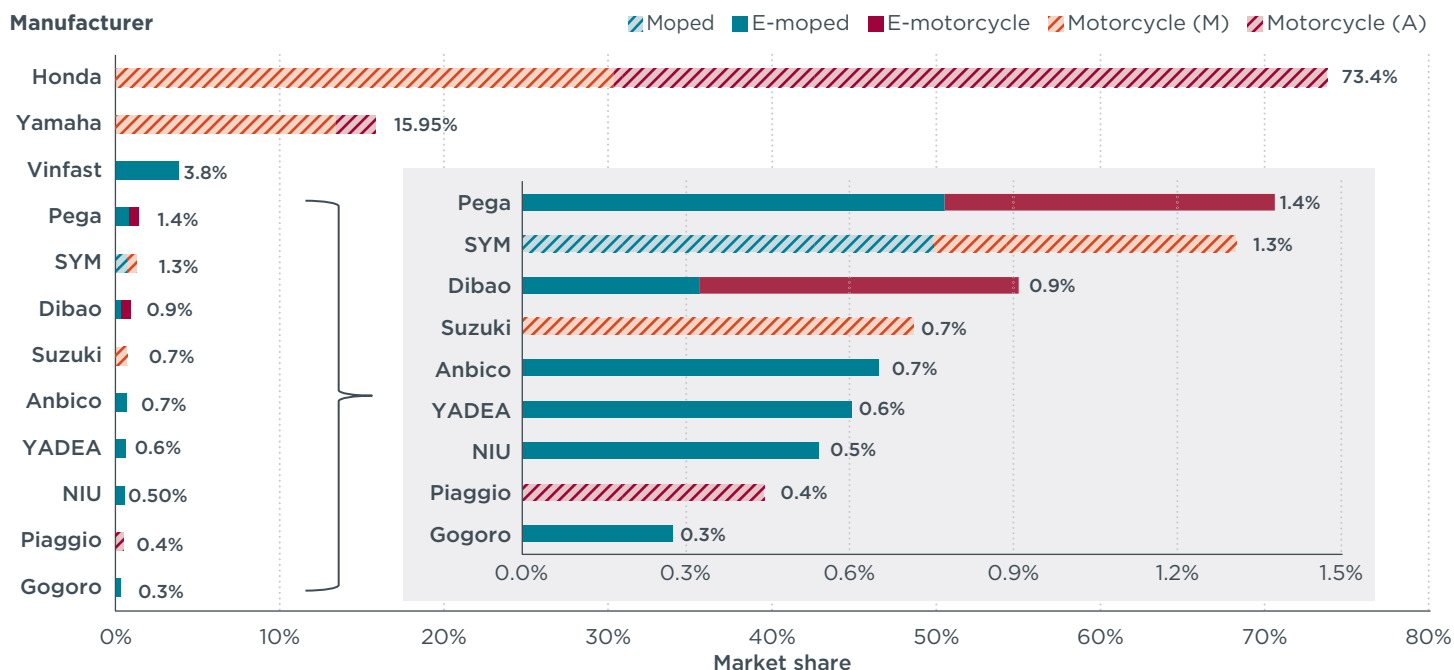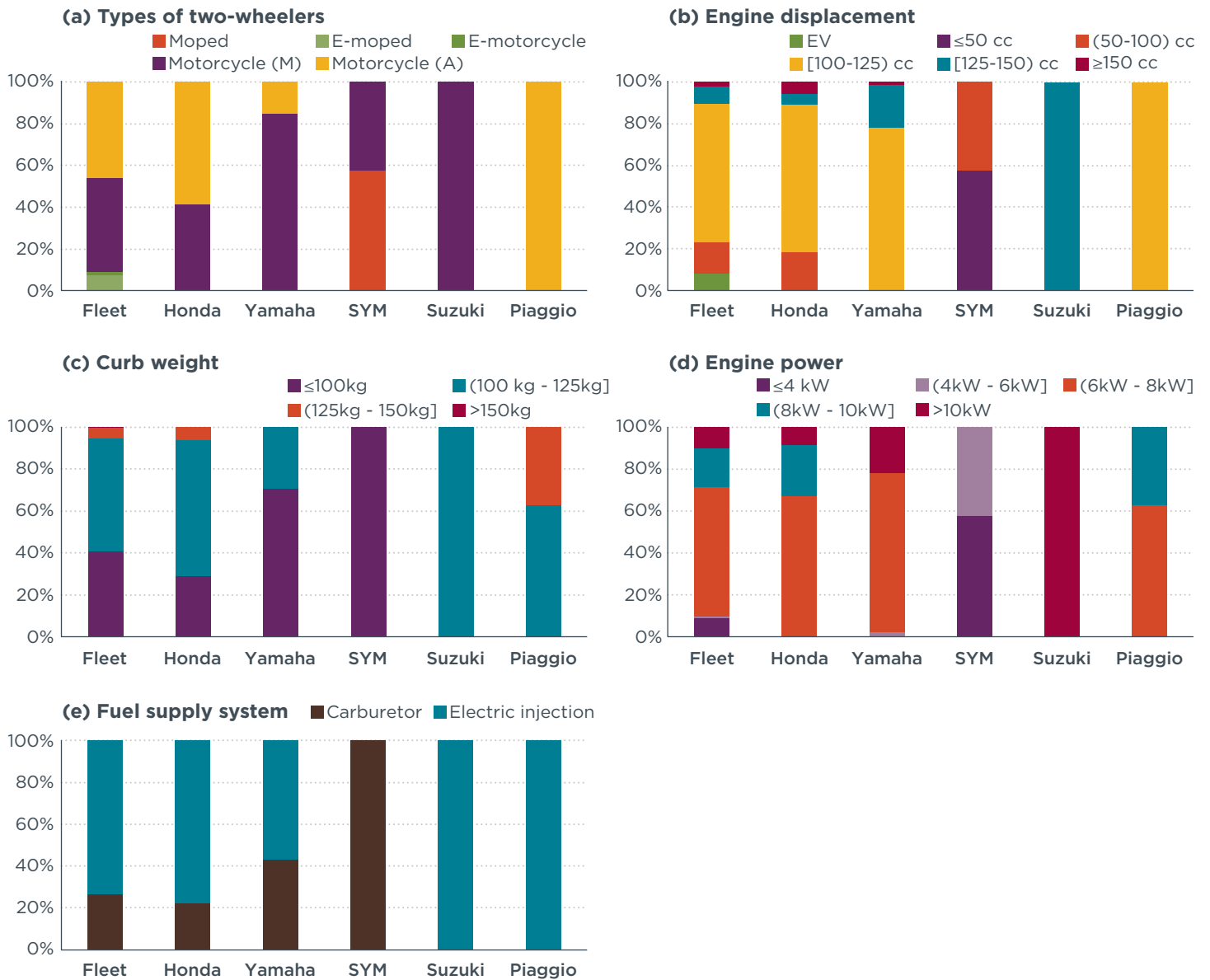
Figure 6. Market share of new two-wheelers by manufacturer, 2020

The fleet sales-weighted averages of all specifications for five major ICE two-wheeler manufacturers are shown in Table 5. These manufacturers represent 91.7% of the two-wheelers sold in 2020. Because more than half of two-wheelers sold by SYM are mopeds, SYM two-wheelers have the smallest engine displacement, lowest fuel consumption, and lightest vehicle weight. Suzuki two-wheelers have the highest engine displacement, while Piaggio two-wheelers have the highest fuel consumption. The characteristics of two-wheeler fleets from Honda and Yamaha, the two largest manufacturers, are relatively similar in terms of engine displacement, curb weight, engine power, and fuel consumption.

Table 5. Sales-weighted averages of ICE two-wheeler specifications by manufacturer, 2020

| Parameter	Fleet	Honda	Yamaha	SYM	Suzuki	Piaggio
Market share (%)	91.7%	73.4%	15.9%	1.3%	0.7%	0.4%
Engine displacement (cc)	117	116	123	69	147	123
Curb weight (kg)	105	107	103	97	109	124
Engine power (kW)	7.0	7.5	7.9	3.4	13.6	8.5
Fuel consumption (l/100 km)	1.92	1.92	1.90	1.67	2.43	2.53
CO_2 emission (g/km)	46.23	26.23	45.72	40.21	58.51	60.92
Top selling model	Vision	Vision	Sirius (R/RC/RL)	Elegant 110	Raider150	Sprint 125

Figure 7 presents the types of vehicles, engine displacement, curb weight, and engine power of two-wheeler fleets by the top five ICE two-wheeler manufacturers. As shown in Figure 7a, Honda and Yamaha sell both types of motorcycles, including manual transmission and automatic transmission models. In contrast, Suzuki sells only motorcycles with manual transmissions, and Piaggio sells only motorcycles with automatic transmissions. SYM is the only manufacturer that sells mopeds. Honda's two-wheeler fleet has a wide range of engine displacement, ranging from 50 cc to more than 150 cc, and the largest share is two-wheelers with engine displacement between 100 cc and 125 cc. Suzuki and Piaggio only sell vehicles with engine displacement of 125 cc to 150 cc and 100 cc to 125 cc, respectively. Piaggio's two-wheelers are heavier than two-wheelers from other manufacturers, whereas SYM's two-wheelers are the lightest. Two-wheelers from Suzuki have the highest engine power that is greater than 10 kW.

(a) Types of two-wheelers

Legend: Moped, E-moped, E-motorcycle, Motorcycle (M), Motorcycle (A)

(b) Engine displacement

Legend: EV, ≤50 cc, (50-100) cc, [100-125) cc, [125-150) cc, ≥150 cc

(c) Curb weight

Legend: ≤100kg, (100 kg - 125kg], (125kg - 150kg], >150kg

(d) Engine power

Legend: ≤4 kW, (4kW - 6kW], (6kW - 8kW], (8kW - 10kW], >10kW

(e) Fuel supply system

Legend: Carburetor, Electric injection

Figure 7. Key parameters of ICE two-wheeler sales by manufacturers in 2020

Figure 7e shows the two-wheeler market of the five major manufacturers segmented by fuel supply technology. All two-wheelers from Suzuki and Piaggio used fuel injection technology, while all two-wheelers from SYM used carburetor technology. Honda and Yamaha offered both carburetor technology and fuel injection technology for their ICE two-wheeler vehicles. 22.3% of Honda's two-wheelers used carburetors, while the remaining 77.7% were fuel injection two-wheeler vehicles. The share of Yamaha's two-wheelers that used carburetor technology remained high at 43.3%, while 56.7% of its two-wheelers used fuel injection technology.

The transmission technologies and gears of ICE two-wheelers sold by manufacturers are presented in Figure 8. Honda and Yamaha sold both two-wheelers with 4-gears and 6-gears, whereas SYM only sold 4-gear vehicles and Suzuki only sold 6-gear vehicles.
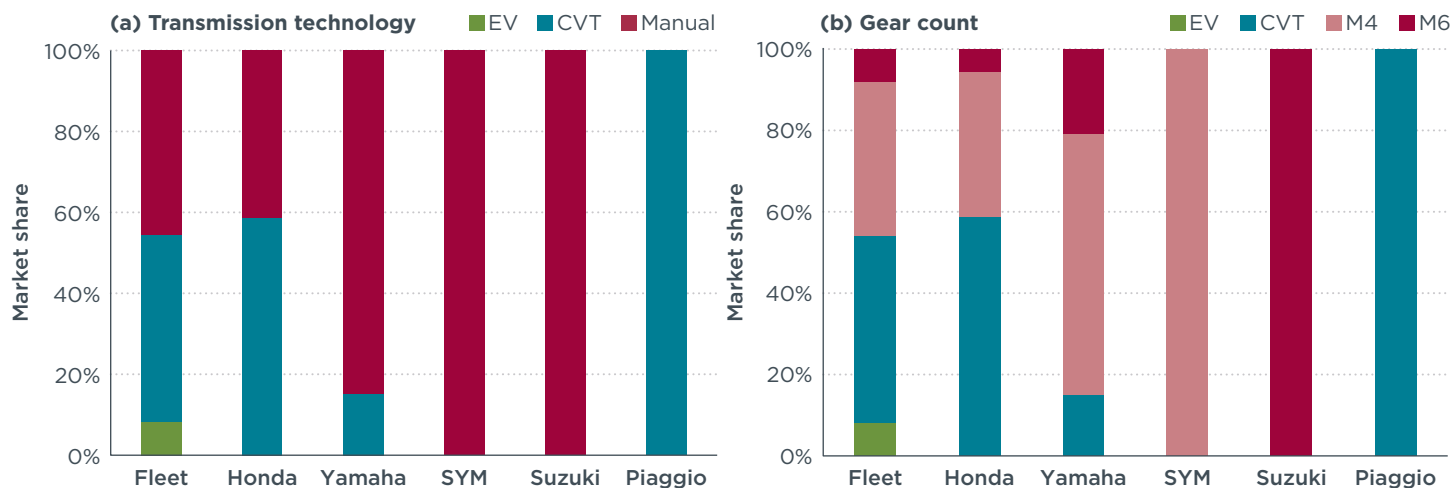
Figure 8. Transmission technologies and gears of ICE two-wheelers sales by manufacturers

Analysis of fleet average fuel consumption

This section analyses the fuel consumption of two-wheelers sold in 2020 by vehicle type, engine displacement, engine power, fuel supply system, and manufacturer. The average fuel consumption in this section is the average fuel consumption that includes the incorporation of E2Ws. Figure 9 shows the average fuel consumption of two-wheeler fleets in 2019 and 2020, plotted as a function of curb weight. Based on our analysis, the average fuel consumption in 2020 fell by 4.3% compared to 2019 (from 1.84 l/100 km in 2019 to 1.76 l/100 km in 2020) mainly because of the increase in E2W uptake. However, there is no significant difference between average fuel consumption of internal combustion two-wheelers in 2019 (1.93 l/100 km) and 2020 (1.92 l/100 km).

(a) 2020

(b) 2019
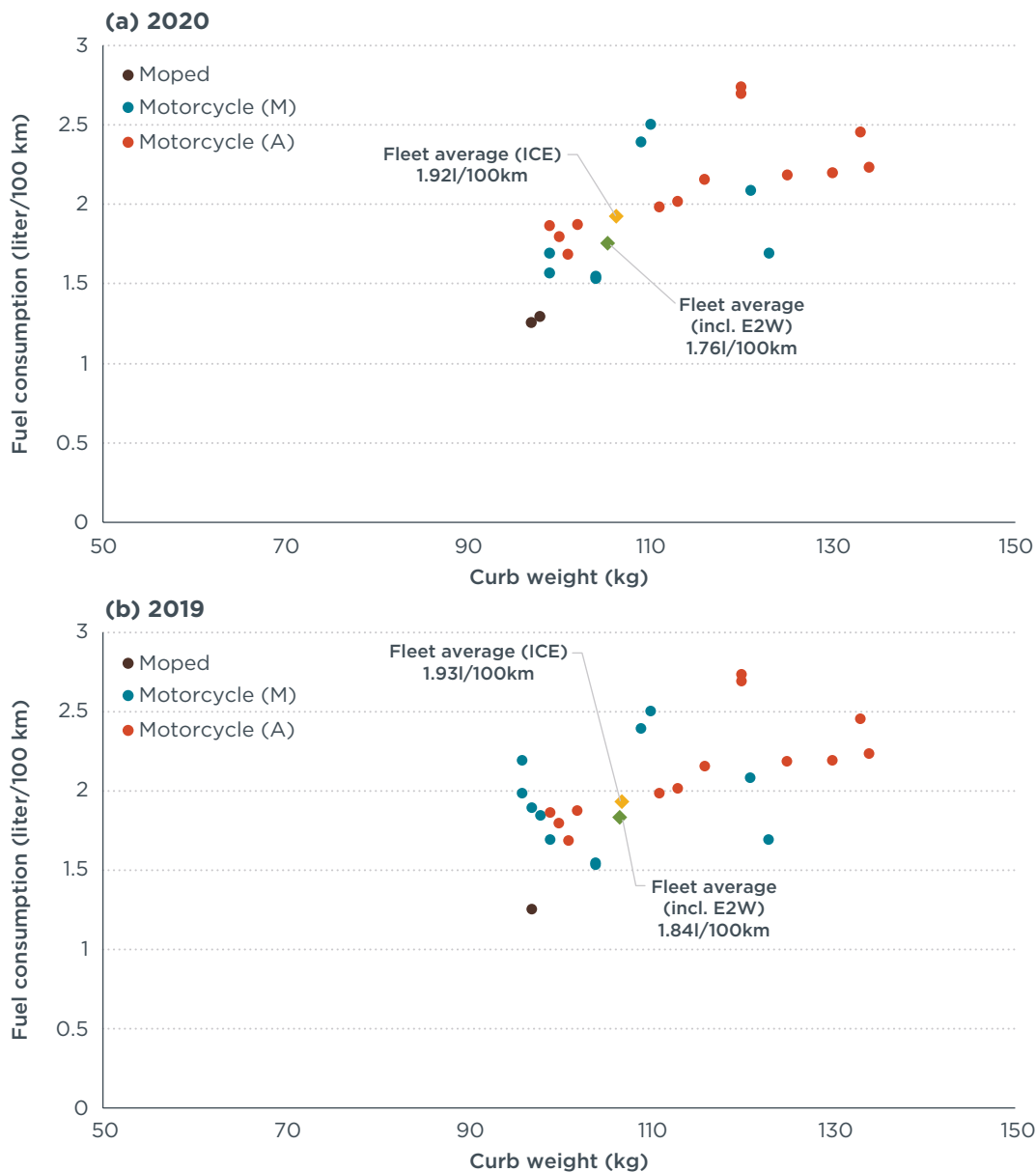
Figure 9. Average fuel consumption as a function of curb weight of different two-wheeler types in 2019 and 2020

Figure 10 and Figure 11 present the fuel consumption of different two-wheeler types as a function of engine displacement and engine power. Mopeds also have the lowest fuel consumption as functions of engine displacement and engine power. The correlation between engine displacement and fuel consumption is quite weak. The average engine power of motorcycles with automatic transmissions is higher than that of motorcycles with manual transmissions and they also have higher fuel consumption. On average, motorcycles with automatic transmissions have the highest fuel consumption.
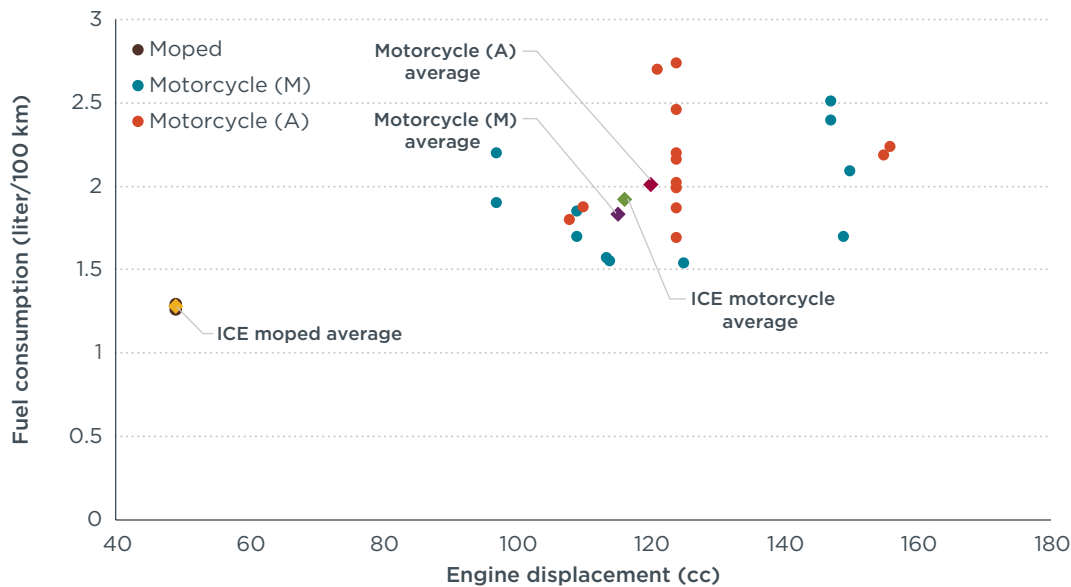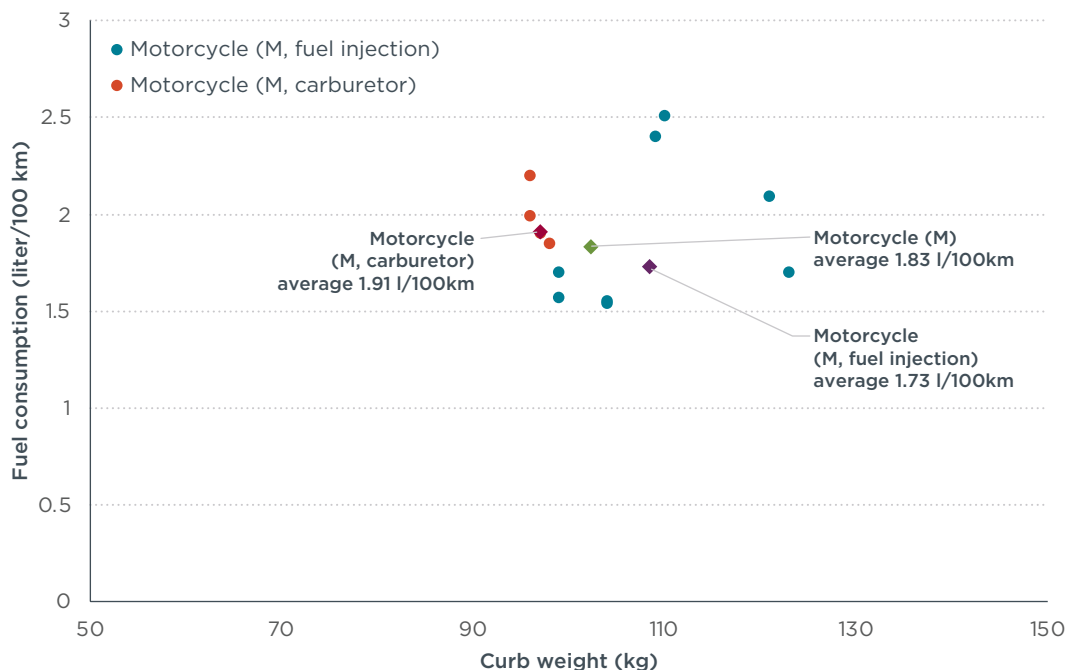
Figure 10. Average fuel consumption as a function of engine displacement of different two-wheeler types in 2020
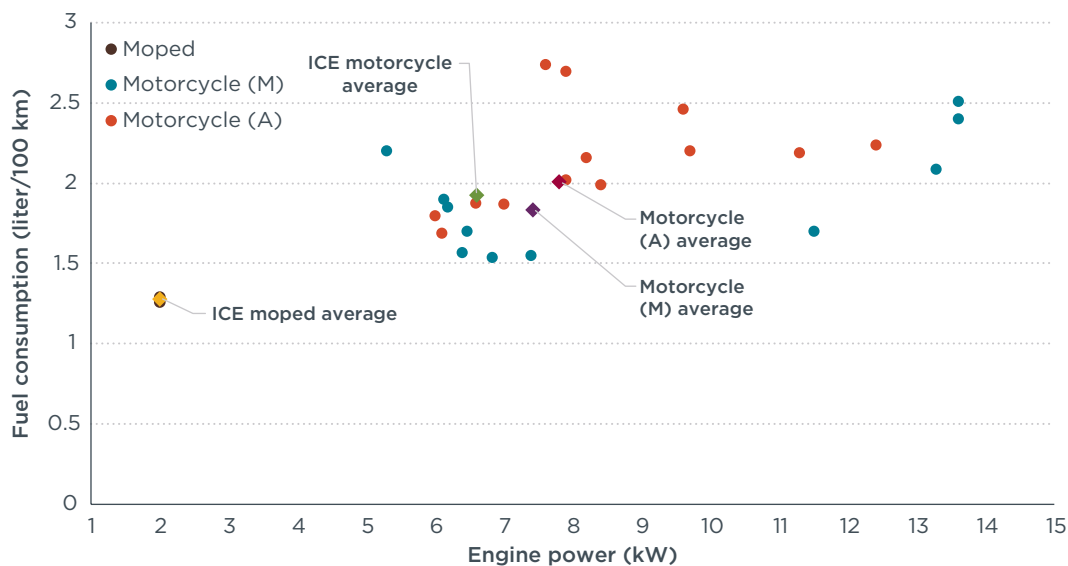
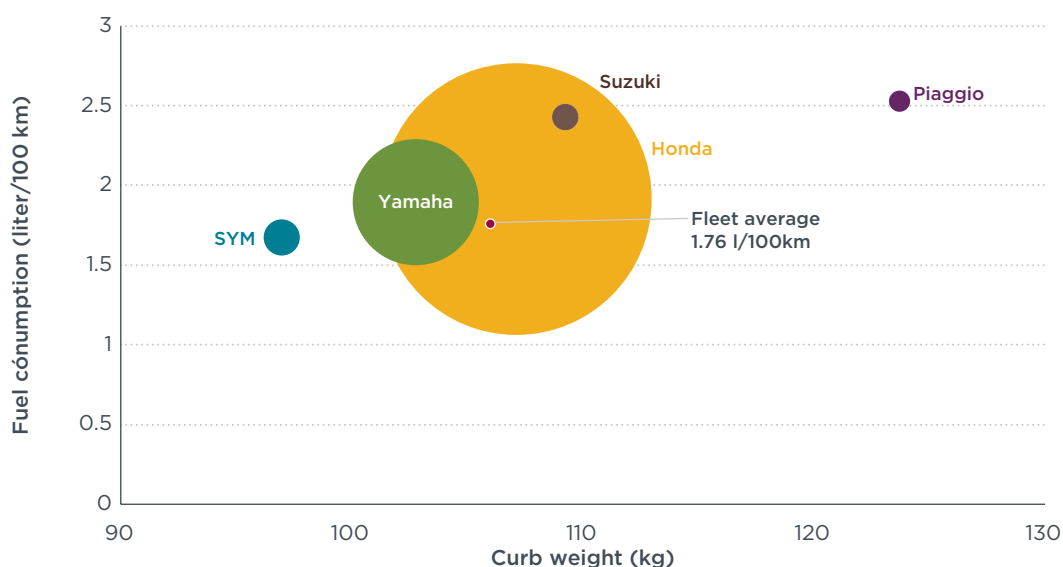**Figure 11.** Average fuel consumption as a function of engine power of different two-wheeler types in 2020

The fuel supply system influences the fuel consumption of two-wheelers. Figure 12 compares motorcycles with manual transmissions and a carbureted engine to those equipped with fuel injection technology. The fuel injection models have 12% lower fuel consumption (1.73 l/100 km) compared to motorcycles with a carburetor (1.91 l/100 km). This shows the potential to reduce the fuel consumption of two-wheelers by shifting from carburetors to fuel injection. Compared with carburetors, electronically controlled port fuel injection offers improved precision of fuel delivery and better response to driver demands. The shift in technology will also provide a significant emissions reduction benefit. Experiments with a 150cc motorcycle show that port fuel injection can reduce CO by 20 percent and HC+NOx by 70 percent.[8] Currently, all mopeds still use a carburetor, whereas motorcycles with automatic transmission are equipped with fuel injection.

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8   Leighton, S., & Ahern, S. (2003). Fuel Economy Advantages on Indian 2-Stroke and 4-Stroke Motorcycles Fitted with Direct Fuel Injection. SAE Technical Paper (2003-26-0019).

Figure 12. Average fuel consumption as a function of curb weight of motorcycles with manual transmission of different engine types in 2020
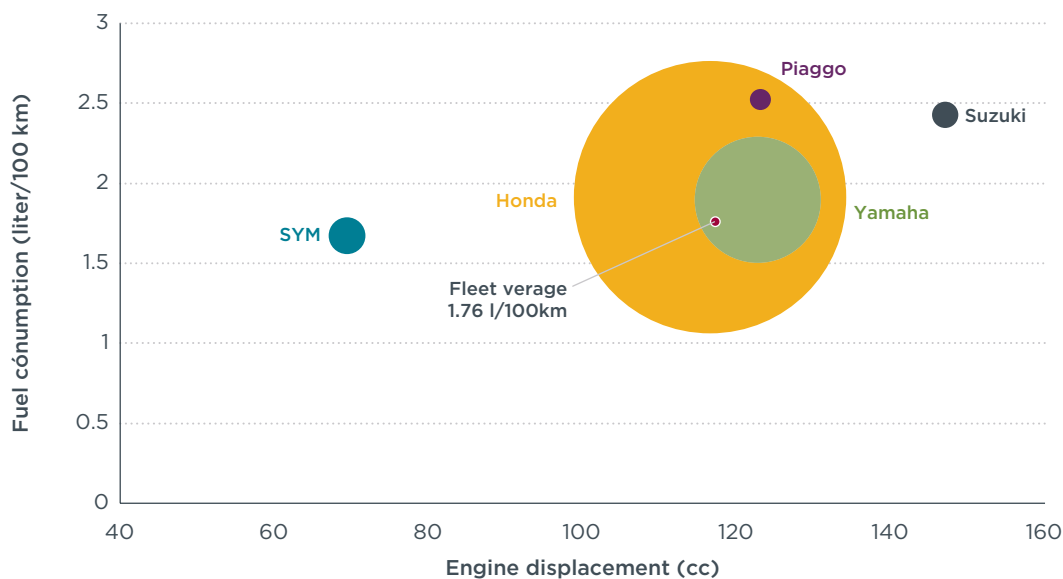
The fuel consumption of two-wheelers sold by five manufacturers is compared in Figure 13. The average fuel consumption of two-wheelers sold in 2020 is 1.76 liter/100 km. Piaggio has the heaviest and highest fuel consumption fleet, whereas SYM has the lightest and lowest fuel consumption fleet. In general, there is a positive correlation between fleet weight and fuel consumption. The manufacturer with the heavier fleet will have higher fuel consumption. However, for two-wheelers from Honda and Suzuki, which show no significant difference in curb weight—the average Honda vehicle weight is only 2 kg (approximately 2%) lighter than the average for the Suzuki fleet—the average fuel consumption of Honda's fleet is 21% lower than that of Suzuki. This suggests that it is possible to reduce fuel consumption through improvements in technology.

Figure 13. Average fuel consumption as a function of curb weight of major two-wheeler manufacturers in 2020
Note: Bubble sizes represent manufacturers' sales volumes in 2020

Figure 14 shows the average fuel consumption of two-wheelers from five manufacturers as a function of engine displacement. Although Piaggio's average engine displacement for two wheelers is lower than Suzuki's, its fleet average fuel consumption is higher than that of Suzuki. Once again, the conclusion is that it is possible to reduce fuel consumption through improvement in technology.

Figure 14. Average fuel consumption as a function of engine displacement of major two-wheeler manufacturers
Note: Bubble sizes represent manufacturers' sales volumes in 2020
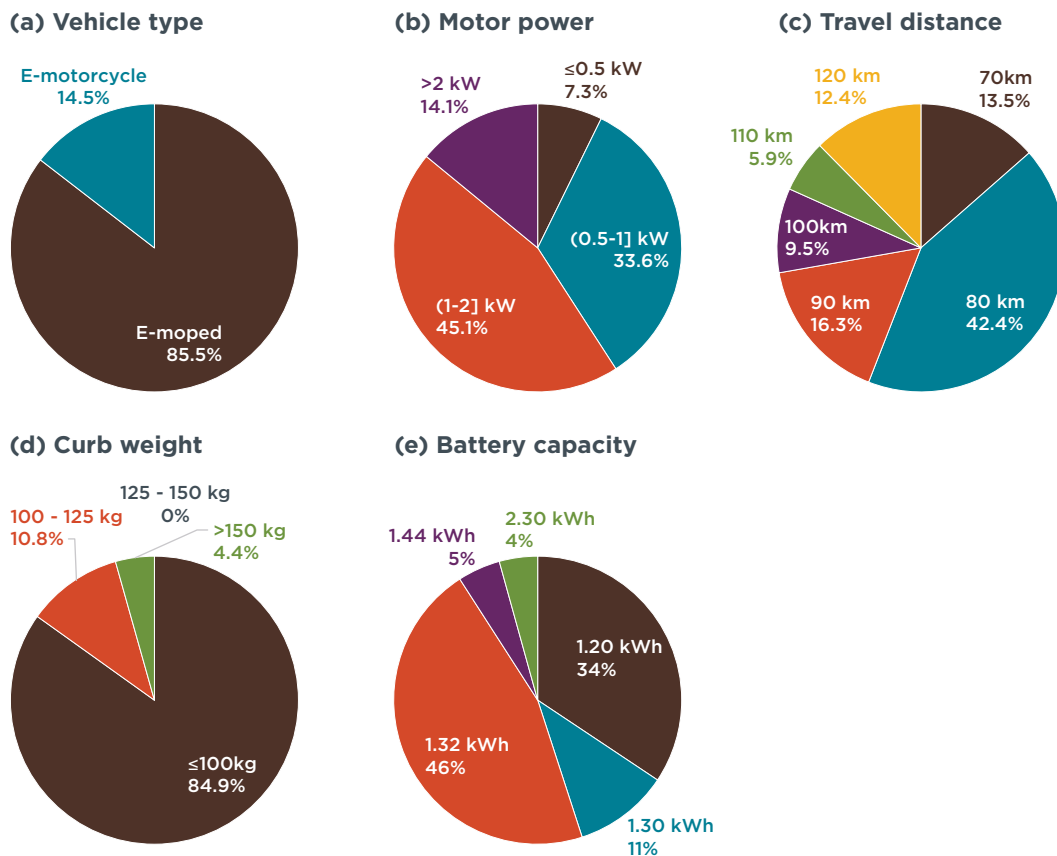
Characteristics of electric two-wheelers

Characteristics of E2W fleet

This section focuses only on electric two-wheelers sold in 2020. According to Vietnam Register, electric 2-wheelers (E2W) in Vietnam number more than 1 million units. E2W sales have increased significantly, from 163,428 in 2019 to nearly 237,000 in 2020. Before 2018, the majority of E2Ws in Vietnam were imported, mainly from China, Japan, and Korea.[9] Since 2018, imported vehicles have decreased significantly, and domestically assembled vehicles have increased sharply. Domestic enterprises have invested strongly in electric vehicle assembly and production as well as distribution agents and after-sales services. An example is VinFast, a relatively new local enterprise that sells electric two-wheelers. It has established a strong position in the E2W market, accounting for 47% of E2W sales in 2020.

Figure 15 presents key characteristics of E2W sales in 2020. 85.5% of the fleet was e-moped, and only 14.5% was e-motorcycle. The data related to E2W characteristics presented in this paper were mainly collected from manufacturers' websites and showroom information. Vehicles with motor power ranging from 0.5 kW to 1 kW, and from 1 kW to 2 kW, were the most common, accounting for 33.6% and 45.1% of the E2W fleet, respectively. The travel distance when fully charged ranged from 70 km to 120 km; 42.4% of E2Ws can travel up to 80 km, and 12% of E2Ws can travel up to 120 km at full charge. As previously mentioned, more than 85% of E2Ws are e-mopeds; therefore, the majority of the E2W fleet is lighter than 100 kg (84.9%). E2Ws with battery at 1.2 kWh and 1.32 kWh are the most popular, with a share of 34% and 46% of Vietnam's E2W market, respectively.

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9   Tuan, L. A. (2021). Study on the criteria development of pilot city selection for e-mobility adoption in Vietnam, presented at the NDC-TIA kick-off workshop, March 2021, City, Vietnam.

(a) Vehicle type

E-motorcycle 14.5%
E-moped 85.5%

(b) Motor power

>2 kW 14.1%
≤0.5 kW 7.3%
(0.5-1] kW 33.6%
(1-2] kW 45.1%

(c) Travel distance

120 km 12.4%
70km 13.5%
110 km 5.9%
100km 9.5%
90 km 16.3%
80 km 42.4%

(d) Curb weight

125 - 150 kg 0%
100 - 125 kg 10.8%
>150 kg 4.4%
≤100kg 84.9%

(e) Battery capacity

1.44 kWh 5%
2.30 kWh 4%
1.20 kWh 34%
1.32 kWh 46%
1.30 kWh 11%

Figure 15. Key characteristics of the E2W fleet sold 2020

E2W characteristics by manufacturer

The market share of the 2020 new E2W fleet is shown in Figure 16. There are 7 major E2W manufacturers in Vietnam. After VinFrast, Pega has the second largest market share, with 17%, following by DIBAO (11%) and Anbico (8%). Gogoro has the smallest market share, with only 3%.

Gogoro 3%
NIU 7%
YADEA 7%
Anbico 8%
DIBAO 11%
Pega 17%
VinFast 47%
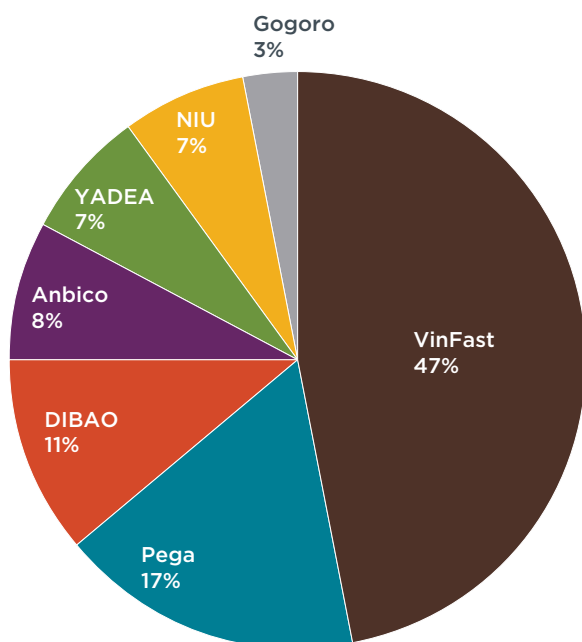
Figure 16. Market share as function of EV manufacturers in 2020

The main features of E2W fleets of seven major E2W manufacturers are shown in Table 6; 8.2% of the total two-wheeler fleet sold in 2020 were E2Ws, which included e-mopeds and E-motorcycles. Pega's E2W has the highest battery capacity with 1.53 kWh, while battery capacities of E2Ws from other manufacturers range from 1.2 kWh to 1.26 kWh. E2Ws from Gogoro are the heaviest with an average curb weight of 122 kg, whereas Dibao vehicles are the lightest. VinFast and NIU have the lowest motor power in the fleet, lower than the average values of the total E2W fleet, at only 0.9 kW and 0.84 kW, respectively. Regarding travel distance with a fully charged battery, vehicles from Gogoro have the greatest range, an average of 110 km, following by Pega vehicles, at 103.4 km.

Table 6. Sales-weighted averages of EV two-wheeler specifications by manufacturers in 2020

Parameter	Fleet	VinFast	Pega	Dibao	Anbico	YADEA	NIU	Gogoro
Market share (%)	8.2%	3.8%	1.4%	0.9%	0.7%	0.6%	0.5%	0.3%
Battery capacity (kWh)	1.28	1.25	1.53	1.20	1.20	1.26	1.20	1.20
Curb weight (kg)	95.7	89.5	112.7	88.1	89.7	102.1	95.0	122.0
Motor power (kW)	1.31	0.9	2.11	1.50	1.23	0.84	2.40	1.20
Range (km/full charge)	88.9	84.5	103.4	88.2	80.3	92.7	80.0	110.0
Top selling model	Klara A2	Klara A2	Aura	Butterfly	GoGo one	E3	NIU	Gogoro 2

Figure 17 presents the travel distance of E2Ws as a function of battery capacity. Pega's vehicles have a higher battery capacity than Gogoro's vehicles, but the range with a fully charged battery is lower than that for Gogoro's E2W.
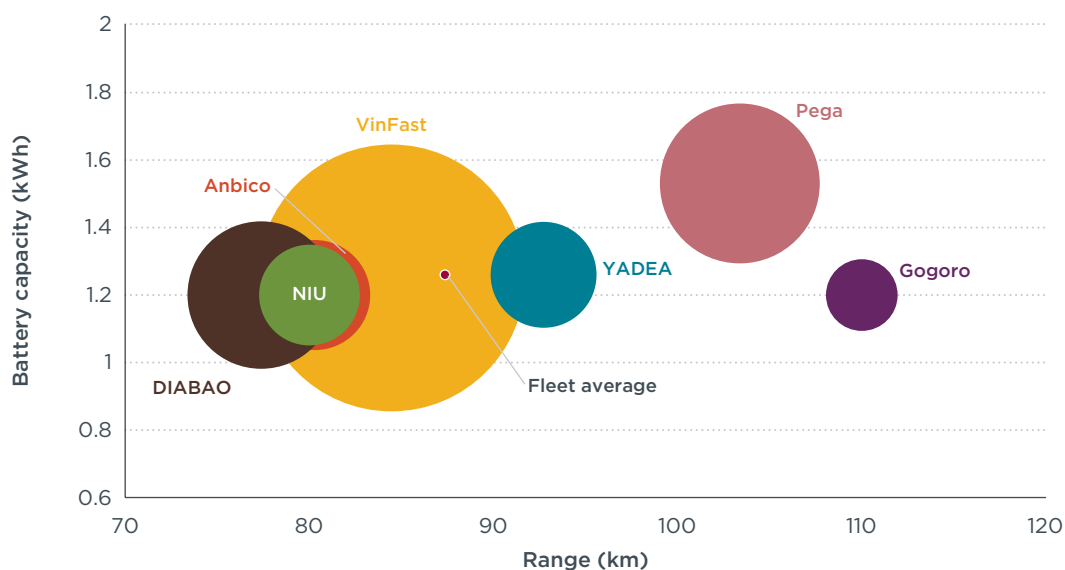
Figure 17. Average battery capacity as a function of range of E2W manufacturers in 2020
Note: Bubble sizes represent manufacturers' sales volumes in 2020

Table 7 lists all electric two-wheeler models sold in 2020. There are seven brand manufacturers with 23 models. Most models are e-mopeds and only 5 are e-motorcycles. Pega and DIBAO are the only 2 manufacturers that sell e-motorcycles, with 2 and 3 models, respectively. In terms of sales trends, YADEA, VinFast, and Gogoro are the three fastest-growing manufacturers, with sales increases of 237%, 159%, and 85% compared with 2019. Most of the electric vehicle models were lighter than 100 kg. Among these, Pega S (from Pega) is the heaviest at 155 kg and LUDO (from VinFast) is the lightest at 68 kg. The maximum speed of most electric vehicle models ranges from 45 km/h to 50 km/h, with the fastest electric motorcycle registering a maximum speed of 65km/h.

The last parameter is vehicle price; the cheapest model is 12.8 million VND and the most expensive is 39.9 million VND. Vehicle prices were collected from showrooms and manufacturers' websites and usually include value-added tax.

Table 7. Key parameters of EV two-wheelers in 2020

OEM	Model	Segment*	Sale in 2020	Change (compared to 2019)		Curb weight (kg)	Battery capacity (kWh)	Range (km)	Max speed (km/h)	Price (million VND, May 2021)
				Model	OEM					
VinFast	Klara A2	E-M	64,300	63%		95	1.40	80	50	30
	KLARA S	E-M	19,050	244%	159%	95	1.32	120	50	39.9
	IMPES	E-M	17,000	135%		75	1.32	70	50	24.6
	LUDO	E-M	10,050	86%		68	1.32	70	35	22.6
Pega	Aura	E-M	14,674	-32%		90	1.20	70	50	15.9
	Pega S	E-MC	10,343	0%		155	2.30	120	65	35
	Pega Xmen	E-M	7,778	1%	-13%	90	1.20	100	50	16.3
	Pega New Tech	E-MC	7,178	8%		123	1.44	90	60	21.7
DIBAO	Butterfly	E-MC	6,782	-18%		85	1.20	100	55	16.7
	Zoomer	E-MC	5,338	11%		80	1.26	90	55	15
	Pansy S	E-M	5,098	13%		90	1.68	100	50	16.9
	Gogo	E-MC	4,809	-3%	-4%	93	1.26	90	55	16
	Gogo SS	E-M	4,333	-13%		95	1.26	90	50	18.3
	Jeek One	E-M	3,586	6%		93	1.20	90	50	18.7
Anbico	GoGo one	E-M	5,570	-12%		90	1.20	90	50	16
	Dina	E-M	5,020	-9%		85	1.20	70	50	12.8
	Valerio X	E-M	4,309	0%	-3%	90	1.20	80	50	15
	Xmen Boss	E-M	4,036	20%		95	1.20	80	50	14.6
YADEA	E3	E-M	7,185	-		94	1.68	80	37	16
	Q5	E-M	5,960	100%	237%	104	1.32	110	47	18
	BuyE	E-M	4,360	273%		113	1.44	90	50	19
NIU	NIU	E-M	15,776	10%	10%	95	1.20	80	45	35
Gogoro	GOGORO 2	E-M	7,990	85%	85%	122	1.20	110	50	15.35

Notes: * E-M: electric moped, E-MC: electric motorcycle
**: Million VND, May-2021

Summary of key findings

Two-wheelers account for more than 90% of all motorized vehicles in Vietnam. Most of the fleet is internal combustion engine vehicles powered by gasoline that generate more than 90% of CO and VOC, and 60% of suspended particles of the total transport modes' emissions. Understanding fleet characteristics and identifying a baseline of fuel consumption are necessary preconditions for crafting any regulation seeking to reduce the future carbon impact of two-wheelers. In this paper, the new two-wheeler fleet sold in 2019 and 2020 is analyzed in detail in terms of market share, fleet characteristics, and fuel consumption. Key findings of the paper are summarized as follows:

The two-wheeler market in Vietnam is dominated by internal combustion engine vehicles, but sales of E2Ws jumped markedly from 2019 to 2020.

» Two-wheelers with internal combustion engines sold in Vietnam are predominantly fueled by gasoline. ICE motorcycles account for the majority of the fleet, at 94.8% in 2019 and 91% in 2020; the shares of vehicles with manual and automatic transmission are distributed evenly. ICE mopeds account for a much smaller market share, at only 0.3% in 2019 and 0.7% in 2020.

» The number of E2Ws increases significantly from 2019 to 2020, from 4.9% of the market in 2019 to 8.3% in 2020. The largest growth is found in the number of e-mopeds, which increased from 3.8% in 2019 to 7.1% in 2020. E-motorcycles account for a very small share of the two-wheeler fleet, at only 1.1% in 2019 and 1.2% in 2020. VinFast has the largest market share of E2Ws sold in 2020, at 47%.

Two-wheeler sales in Vietnam are highly concentrated among several models and manufacturers.

» The top 10 best-selling two-wheeler models account for 76.5% of the market. The two biggest-selling manufacturers are Honda and Yamaha; 89.3% of two-wheelers sold in 2020 are from these two manufacturers. Therefore, any efficiency technology improvements in popular two-wheeler models or technology innovation from major manufacturers, especially these two, would reduce fleet average fuel consumption considerably.

» Motorcycles with engine displacement between 50 cc to 125 cc are dominant in the new two-wheeler fleet sold in 2020, accounting for 80.7%. Only 2.3% of the fleet has engine displacement greater than 150 cc.

The potential for fuel consumption reduction of two-wheelers in Vietnam is great, through both ICE technologies and electrification.

» The average fuel consumption in 2020 fell by 4.3% compared to 2019 (from 1.84 l/100 km in 2019 to 1.76 l/100 km in 2020) mainly because of the increasing penetration of E2Ws in 2020. There is no significant difference between average fuel consumption of internal combustion two-wheelers in 2019 (1.93 l/100 km) and 2020 (1.92 l/100 km).

» Motorcycles with automatic transmission technology have the highest fuel consumption among two-wheeler types, and it is higher than the average fuel consumption of the total fleet. Mopeds have the lowest fuel consumption with low vehicle weight and engine power, which is much lower than the fleet's average fuel consumption.

» A wide range of fuel consumption levels is observed for two-wheeler models with similar weight and engine power, which indicates the potential for technology improvements in less-efficient models. Fuel supply technology affects fuel consumption of motorcycles significantly; motorcycles using fuel injection technology have on average 12% lower fuel consumption than motorcycles using carburetor technology. Shifting from carburetor to fuel injection would not only reduce fuel consumption but also significantly reduce CO, HC, and NOx emissions.

» Eleven out of twelve manufacturers in this study produce only ICE two-wheelers or only electric two-wheelers. SYM fleet has the lowest fuel consumption with 1.67 l/100 km because 57.5% of two-wheelers sold by SYM are mopeds. Yamaha has the second most efficient fleet, with an average fleet fuel consumption of 1.9 l/100 km, followed by Honda at 1.92 l/100 km. Piaggio's two-wheeler fleet has the highest average fuel consumption, with 2.53 l/100 km. Introducing electric two-wheelers to the market will allow manufacturers that provide only ICE two-wheelers to significantly reduce the average fuel consumption of their fleets.