PASSENGER CARS

Overall Trends

1 Introduction

In 2022, despite the spread of the highly contagious Omicron strain of the COVID-19 novel coronavirus that surfaced in 2020, many countries gradually lifted lockdowns and eased restrictions on travel, paving the way for a recovery in economic activities. In contrast, the zero-COVID policy maintained by China until December 2022, which resulted in locking down cities and imposing restrictions on travel, had a major international impact as the slowdown in domestic demand and plant stoppages disrupted the global supply chain. Moreover, the invasion of Ukraine launched by Russia in February 2022 raised the prices of crude oil, natural gas, and other forms of energy, as well as of foodstuffs such as wheat, and played a major role in increasing the cost of living throughout the world.

In the automobile market, the ongoing shortage of semiconductors, disruption of the supply chain, and other issues gradually became less severe in the second half of 2022, and worldwide vehicle production exceeded that of the preceding year. Although still below 2019 pre-COVID levels, vehicle production, which had stagnated during the pandemic, is exhibiting signs of recovery.

Among automaker technology trends, the introduction of four new BEV models in Japan, including battery electric mini-vehicles expected to spur BEV adoption in the Japanese market, highlighted environmental technologies amid the gradual global shift toward BEVs to achieve carbon neutrality. In addition, the fast pace of functionality enhancements resulting from software or advances in automated driving and connected technologies led to the introduction of models that enable post-purchase updates to on-board software via technologies such as over the air (OTA) communication, as well as of a diverse array of new technologies with the potential to eventually become standards.

2 State of Vehicle Production, Sales, and Exports

2.1. State of Production in Leading Manufacturing Countries

The number of passenger cars produced worldwide in 2022 was 71.02 million vehicles, an increase of 4.58 million vehicles (106.9%) compared to 2021 (Table 1). After falling precipitously due to the impact of the COVID-19 pandemic in 2020, production has gradually been recovering, but has yet to return to the 2019 pre-pandemic level. Underlying factors include the shortage of semiconductors and other parts that has continued since 2021, decreased production in Russia and Ukraine due to the former's invasion of the latter, and the inflationary impact of higher energy and foodstuffs prices.

In Russia, where the invasion of Ukraine resulted in interrupted part deliveries due to sanctions as well as in foreign manufacturers leaving the country, production dropped significantly by 33.2% compared to 2021.

In the various European countries, factors such as the shortage of parts, disrupted supply chain, rising energy prices and transportation costs triggered by the Russian invasion of Ukraine, along with a decrease in subsidies, affected sales and production, which remained essentially the same at 97.9% of the 2021 level.

In India, a partially restored semiconductor supply and the end of the COVID-19 pandemic restarted economic activities, and increased demand boosted production to 122.3% of the 2021 level, exceeding the 2019 level to set a record high.

In Brazil, the impacts of factors such as the shortage of semiconductors and higher loan interest rates due to an increase in the policy interest rate caused a drop in demand, resulting in a weak recovery as production reached 106.6% of the 2021 level, but remained substantially below the 2019 pre-COVID level.

In China, the zero-COVID policy remained in effect,

Table 1 Passenger Car Production in Leading Manufacturing Countries

	2022	Compared to previous year (%)	2021	2020	2019
Japan	6,566,318	99.2	6,619,202	6,960,409	8,328,756
U.S.	9,739,891	110.3	8,828,090	8,550,513	10,522,753
Canada	1,217,837	110.5	1,102,498	1,361,904	1,898,546
Europe	10,599,634	97.9	10,825,437	11,474,186	15,351,566
Germany	3,431,600	111.6	3,075,543	3,509,500	4,728,116
UK	775,014	90.2	859,571	920,649	1,303,135
France	872,510	101.2	862,449	866,398	1,473,339
Italy	472,326	96.0	492,151	475,623	587,366
Spain	1,625,668	87.2	1,863,705	1,838,474	2,467,527
Russia	448,897	33.2	1,352,740	1,260,517	1,523,594
South Korea	3,399,038	108.6	3,129,012	3,174,728	3,612,587
China	23,519,449	111.9	21,010,477	19,598,869	20,958,175
India	4,438,425	122.3	3,628,267	2,849,841	3,623,167
Brazil	1,821,963	106.6	1,708,546	1,609,294	2,449,347
World total	71,023,061	106.9	66,438,702	64,453,959	78,007,299

Note 1 : The production unit numbers from Japan were obtained from Japan Automobile Manufacturers Association data.
Note 2 : Numbers for other countries were obtained from the applicable collated MarkLines data.
Note 3 : The values for Europe are the total for the EU automobile producing nations (15 countries) and the U.K. EU automobile producing nations (15 countries) and the U.K.: Germany, the U.K., France, Spain, Italy, Portugal, Belgium, the Netherlands, Austria, Sweden, Finland, the Czech Republic, Slovakia, Hungary, Romania, and Slovenia.
Note 4 : The totals include the SUVs, MPVs and other light-duty trucks treated as passenger vehicles in the U.S. and Canada.
Note 5 : Including the SUVs and MPVs treated as passenger vehicles in South Korea, China, and India.
Note 6 : The global total consists of the sum of available MarkLines collated data for all countries, including the major countries above. The totals include the SUVs, MPVs and other light-duty trucks treated as passenger vehicles.

Table 2 Passenger Car Production in Japan

	2022	Compared to previous year (%)	2021	2020	2019
Ordinary trucks	4,063,250	97.5	4,165,631	4,192,767	5,317,165
Light-duty trucks	1,201,978	102.8	1,169,284	1,409,994	1,538,380
4-wheeled mini-vehicles	1,301,128	101.3	1,284,330	1,357,650	1,473,211
Total	6,566,356	99.2	6,619,245	6,960,411	8,328,756

Source: Japan Automobile Manufacturers Association (JAMA)

delaying parts procurement and impacting production volume, but various policies, including a preferential tax scheme that reduced the purchase tax on passenger cars and subsidies for automobile purchases, led to a recovery in demand, resulting in a production that rose to 111.9% of the 2021 level and exceeded the 2019 level.

Although the U.S. has been recovering from the pandemic, the higher loan interest rates stemming from the raising of the federal interest rate, in conjunction with the shortage of semiconductors, resulted in a production volume of 110.3% of the 2021 level, still falling short of the 2019 level.

These statistics take regional particularities into account and count SUVs and other light-duty trucks as passenger vehicles.

2. 2. State of Japanese Vehicle Production, Exports, and Sales

(1) Production

Passenger car production in Japan was 6.57 million vehicles, or 99.2% of the 2021 production (Table 2). As the spread of the highly infectious Omicron variant of COVID led to repeated ebbs and flows in cases of infection, the scope of restrictions on movement (declaring a state of emergency, for example), was limited, and the implementation of infection prevention measures enabled production to continue. At the same time, the impact of the shortage of semiconductors since the previous year continued to be felt, and there were stoppages in production due to insufficient parts supply. Although a gradual improvement was observed in the latter half of 2022, production volume, sales volume in Japan, and export volume all remained low.

(2) Exports

The number of exported passenger vehicles in 2022 was 3.32 million vehicles, representing 98.6% of the 2021

Table 3 Number of Passenger Cars Exported from Japan According to Destination

	2022	Compared to previous year (%)	2021	2020
North America	1,391,821	95.2	1,461,382	1,517,169
Europe	519,159	93.6	554,636	663,785
Oceania	365,722	96.6	378,403	320,707
Asia	463,661	92.9	499,167	469,419
Middle-East	343,718	125.3	274,232	263,710
Central America	129,293	124.4	103,943	102,048
South America	65,682	109.6	59,936	38,194
Africa	39,187	117.0	33,487	30,582
Others	3,142	130.7	2,404	2,385
Total	3,321,385	98.6	3,367,590	3,407,999

Source: Japan Automobile Manufacturers Association (JAMA)

Table 4 Passenger Car Sales in Japan

	2022	Compared to previous year (%)	2021	2020
Ordinary trucks	1,346,229	93.1	1,446,655	1,370,755
Light-duty trucks	877,074	92.0	953,207	1,108,077
4-wheeled mini-vehicles	1,224,994	96.0	1,275,836	1,331,149
Total	3,448,297	93.8	3,675,698	3,809,981

Source: Japan Automobile Manufacturers Association (JAMA)
Note: The classification criteria of the sales statistics are based on the license plate number (excluding mini-vehicles).

figure (Table 3). Economic activity is slowly recovering from the pandemic, but the continued shortage of semiconductors and parts supply has kept production volume at the same level as the previous year, and the export volume has similarly remained about the same as in 2021. In addition, the rise in energy and foodstuff prices stemming from the Russian invasion of Ukraine, along with the inflation triggered by higher interest rates, led to sluggish results in the 90% range for North America and Europe. The increase in oil prices stimulated economic recovery in the Middle-East, primarily in oil-producing countries, boosting exports to 125%. Nevertheless, these figures are still short of the 2019 level.

(3) Sales

Sales of passenger vehicles in Japan were 3.45 million units, or 93.8% compared to 2021 (Table 4). With the ongoing semiconductor shortage and lower production delaying the shipment of new vehicles, sales remained stagnant, remaining below the 2020 major drop in production and sales caused by the pandemic for a second consecutive year.

(4) Used Vehicle Sales

Sales of used vehicles in Japan were 5.26 million units, representing 93.5% of the 2021 figure (Table 5). Demand for used vehicles, which can be delivered rapidly, rose as the supply constraints imposed by the shortage of semiconductors led to long delivery times for new vehicles. However, insufficient stock drove the used vehicle market price up, and the volume of used vehicle sales fell below that of 2021.

Table 5 Used Vehicle Sales in Japan

	Ordinary trucks	Light-duty trucks	4 -wheeled mini-vehicles	Total	Compared to previous year (%)
2012	1,688,606	1,826,335	2,133,725	5,648,666	109.0
2013	1,666,732	1,740,725	2,255,560	5,663,017	100.3
2014	1,630,421	1,653,214	2,367,235	5,650,870	99.8
2015	1,668,429	1,602,719	2,354,077	5,625,225	99.5
2016	1,729,194	1,564,982	2,322,533	5,616,709	99.8
2017	1,802,956	1,588,747	2,414,874	5,806,577	103.4
2018	1,834,306	1,523,537	2,449,940	5,807,783	100.0
2019	1,885,765	1,485,339	2,504,576	5,875,680	101.2
2020	1,898,616	1,443,889	2,394,963	5,737,468	97.6
2021	1,872,619	1,373,160	2,386,963	5,632,742	98.2
2022	1,781,467	1,257,659	2,225,061	5,264,187	93.5

Sources: Japan Automobile Dealers Association (JADA) for ordinary and light-duty vehicles, and the Japan Light Motor Vehicle and Motorcycle Association for mini-vehicles.

Table 6 Imported Vehicle Sales in Japan

Ranking in 2022	Ranking in 2021	Brand	2022 (Units)	2021 (Units)	Compared to previous year (%)
1	1	Mercedes-Benz	52,391	51,722	101.3
2	4	VW	32,229	35,215	91.5
3	3	BMW	30,887	35,905	86.0
4	5	Toyota (vehicles produced outside Japan)	28,607	27,340	104.6
5	2	Nissan (vehicles produced outside Japan)	26,901	43,872	61.3
6	6	Audi	20,750	22,535	92.1
7	7	BMW Mini	19,208	18,211	105.5
8	8	Volvo	16,166	16,638	97.2
9	9	Jeep	9,871	14,294	69.1
10	11	Renault	8,618	7,666	112.4
11	10	Peugeot	8,552	12,072	70.8
12	12	Porsche	7,193	7,009	102.6
13	16	Others	5,923	5,232	113.2
14	18	Mazda (vehicles produced outside Japan)	5,820	2,860	203.5
15	13	Fiat	5,768	6,995	82.5
16	15	Citroën	4,878	5,894	82.8
17	17	Land Rover	4,496	4,784	94.0
18	20	Abarth	2,646	2,489	106.3
19	19	Mitsubishi (vehicles produced outside Japan)	2,607	2,619	99.5
20	14	Honda (vehicles produced outside Japan)	2,139	6,188	34.6
21	21	Alfa Romeo	1,627	2,341	69.5
		Total for non-Japanese manufacturers	242,226	259,752	93.3
		Total of vehicles produced outside Japan	67,533	84,800	79.6
		Total	309,759	344,552	89.9

Source: Statistics of the Japan Automobile Importers Association (JAIA)
The total includes ranks 21 and below.

(5) Imported Vehicle Sales

The number of vehicles imported in Japan was 310,000, or 89.9% of 2021 levels (Table 6).

For non-Japanese automakers, the long delivery delays due to the shortage of semiconductors, the rising cost of

Table 7 Passenger Car Sales in Leading Manufacturing Countries and share of Japanese Vehicles

	2022			2021			Compared to previous year	
	No. of units sold	Japanese vehicles	Share of Japanese vehicles	No. of units sold	Japanese vehicles	Share of Japanese vehicles	No. of units sold	Japanese vehicles
Japan	3,448,297	3,207,539	93.0%	3,675,698	3,417,061	93.0%	93.8%	93.9%
US	13,927,417	4,759,519	34.2%	15,098,659	5,796,425	38.4%	92.2%	82.1%
Canada	1,524,283	495,906	32.5%	1,663,850	613,999	36.9%	91.6%	80.8%
Brazil	1,556,634	250,275	16.1%	1,535,853	267,449	17.4%	101.4%	93.6%
China	23,240,235	4,217,672	18.1%	21,090,235	4,452,387	21.1%	110.2%	94.7%
India	3,792,356	1,866,685	49.2%	3,082,421	1,625,571	52.7%	123.0%	114.8%
Russia	687,370	58,980	8.6%	1,666,780	244,513	14.7%	41.2%	24.1%
Total for Europe	11,214,569	1,431,110	12.8%	11,711,371	1,490,835	12.7%	95.8%	96.0%
UK	1,614,063	257,629	16.0%	1,647,181	264,258	16.0%	98.0%	97.5%
Germany	2,651,357	203,476	7.7%	2,622,132	216,148	8.2%	101.1%	94.1%
France	1,529,185	160,399	10.5%	1,659,146	166,988	10.1%	92.2%	96.1%
Italy	1,316,700	166,891	12.7%	1,463,592	184,586	12.6%	90.0%	90.4%

Note 1 : The Japanese sales figures are collated from figures obtained from the Japan Automobile Dealers Association (JADA) for ordinary and light-duty vehicles, from the Japan Light Motor Vehicle and Motorcycle Association for four-wheeled mini-vehicles, and from the Japan Automobile Importers Association for imported vehicles. Imported Japanese brand vehicles are counted as Japanese vehicles.
Note 2 : Numbers for other countries were obtained from the applicable collated MarkLines data. The proportion of Japanese vehicles was collated by picking out Japanese brand vehicles in each country.
Note 3 : The totals include the SUVs, MPVs and other light-duty trucks treated as passenger vehicles in the U.S. and Canada.
Note 4 : Including the SUVs and MPVs treated as passenger vehicles in China, and India.
Note 5 : Europe includes the 27 EU nations, the three EFTA nations (Iceland, Norway, and Switzerland), and the U.K. Of those, figures for Cyprus, Latvia, Lithuania, Malta, and Iceland have not been included as no data is available.

materials, and repeated price increases resulting from the depreciation of the yen caused sales to fall by 93.3% compared to the previous year. Japanese automaker sales of vehicles produced outside Japan, which had increased considerably in 2021, fell drastically to 79.6% of the previous year's figures.

By manufacturer, Mercedes-Benz, the 2021 leader, maintained its top position with roughly equivalent sales of 101.3%, while Volkswagen and BMW, who were in the top 5 in the previous year, saw sales decreases to 91.5% and 86.0% of the 2021 level, but remained at the same rank. Nissan sales (vehicles produced outside Japan) fell to 61.3% of the 2021 figures, dropping down to fifth place from the 2021 second place.

2. 3. Vehicle Sales in Markets outside Japan

Table 7 shows passenger car sales in leading manufacturing countries along with the share of Japanese vehicles. Although cases of infection increased due to the spread of the highly contagious Omicron variant of COVID, widespread vaccination and other measures led many countries to relax their restrictions on movement, and economic activity slowly regained ground. At the same time, parts supply constraints stemming from the shortage of semiconductors, higher energy and foodstuff prices caused by the Russian invasion of Ukraine, and inflation resulting from rising interest rates all had an impact on sales. The impact of the individual factors varies from one country to the next, leading to different trends in sales increases or decreases in various countries.

In India, a less severe semiconductor shortage and an increase in income drove up demand for automobiles, leading to sales reaching 123.0% of the 2021 level, their highest level ever.

In China, despite restrictions on movement imposed by the zero-COVID policy, a decrease in the impact of the semiconductor shortage, the tax rebate policy of the Chinese government, and regional government policies to promote automobile sales, brought sales up to 110.2% of the 2021 level.

In Russia, economic sanctions against the invasion of Ukraine and the withdrawal of foreign manufacturers caused sales to plummet to 41.2% of the 2021 level.

In other regions, sales were roughly equivalent to the previous year at 90 to 100% of the 2021 level.

Japanese vehicles followed the overall trend, but in the U.S. and Canada, Japanese manufacturers were slower than U.S. manufacturers to start recovering from the semiconductor shortage, and sales only reached 80% of the 2021 level. In China, where new energy vehicles (NEVs) are gaining prominence, Japanese vehicles failed to gain a greater share of the market and sales were limited to 94.7% of the 2021 level.

3 Product Technology Trends

This section presents a chronological summary of product technology trends (Tables 8 and 9) found in the

Table 8 Main Product Technology Trends in Ordinary and Light-Duty Automobiles Produced in Japan in 2022

Release date	Type	Manufacturer	Major details
January 12	Lexus LX (complete redesign)	Toyota	This model offers a fun and high quality movement experience under any conditions thanks to the marriage of traditional off-road performance with the full realization of the Lexus Driving Signature on-road performance. The identity of the model was reinvented through aspects such as reducing weight by approximately 200 kg with the new GA-F platform while maintaining the body-on-frame structure, and realizing a high-rigidity body through digital development in an effort to secure reliability, durability and rough road performance. Equipping the vehicle with a high power, high torque V6 3.5 -liter twin turbocharger gasoline engine, the electronically controlled brake (ECB) system, and electric power steering (EPS) provides driving performance that enables customers to fully enjoy Lexus driving both on- and off-road. The reinvented identity and new powertrain help enhance environmental performance by cutting CO2 emissions during vehicle use by approximately 20 % in terms of the total number of vehicles worldwide compared to the previous model, thereby contributing to the realization of a carbon neutral society. This model uses the new Active Height Control (AHC) suspension and the Adaptive Variable Suspension (AVS) system. Despite being a body-on-frame model, it offers a high level of controllability and superior ride comfort without sacrificing its traditional off-road performance and vehicle stability. It is also the first Lexus model to adopt a fingerprint recognition start switch, thereby reducing the risk of theft.
January 13	Noah/Voxy (complete redesign)	Toyota	This model was brought into the world as a minivan that makes everyone pack everything they want and go out more comfortably, more conveniently, and with greater peace of mind. Further enhancements to touted features such as the excellent packaging and great ease of use have been complemented by the installation of the latest systems to boost the appeal of the minivan. The Proactive Driving Assist active safety system anticipates risks based on the driving situation and assists with steering and brake operations that prevent the vehicle from getting too close to pedestrians, cyclists, or parked vehicles. The system also assists with slowing down for a preceding vehicle or curve ahead, reducing the burden of constantly switching from one pedal to the other. The Advanced Drive (support during traffic congestion) advanced driving assistance system activates when a certain set of conditions, including driving on a highway when the radar cruise control and lane tracing assist systems are activated and the is driver facing forward, are met. Assisting with recognition, decision-making, and vehicle operation reduces fatigue during congestion and helps the driver drive safely and pay greater attention to the surroundings. In addition, Advanced Park (with remote function), which enables drivers outside the vehicle who are carrying their smart keys to move it into or out of a parking spot using a dedicated smartphone application, has been added. This improves ease of use when parking in situations such as wanting to let children or elderly people get in or out in a wide space, or taking things out of the trunk. The next-generation hybrid system uses a 1.8 -liter inline four-cylinder engine, and all electric modules have been revamped. The higher power motor and battery, as well as increased system efficiency, provide a whole new level of both pleasant acceleration and superb fuel efficiency. The Software Update function enables regular updates to the latest software version using either wireless communication or a wired connection at the dealer. On-board Wi-Fi turns the vehicle into a Wi-Fi spot. This service does not impose any limit on data volume and makes it possible to connect smartphones or game consoles to the Internet.
April 21	Escudo (hybrid system added)	Suzuki	The duration and speed range of EV driving has been expanded by adjusting the voltage of the hybrid system, the capacity of the lithium-ion battery, the maximum power of the motors, and the torque. This model features regenerative brakes that efficiently recharge the battery when braking, as well as EV driving in reverse. In addition to being the first vehicle in Japan to adopt the 6 AGS transmission that provides efficient driving force transmission and imparts a sense of directness to the acceleration feel, this model is also equipped with high power motors offering greater power and torque.
May 12	bZ4 X (new model)	Toyota	This first full Toyota BEV provides carbon neutrality-oriented option and is gradually being introduced to the market based on conditions in various regions around the globe. It embodies the novelty, attractiveness of driving, confidence, and safety unique to BEVs. The dedicated BEV platform built on the e-TNGA concept has been jointly developed with Subaru to create an appealing vehicle that offers a distinctive BEV smooth driving performance in accordance with driver intent, and retains the rough road performance of a full-fledged SUV while also offering the expansive interior space of the next highest grade. Aerodynamic performance and reduced body and unit weight are complemented with the use of a heat pump air conditioner and a radiation heater for front seat occupants to reduce energy consumption even when not driving. All variants are offered through leases to alleviate concerns about BEVs and contribute to carbon neutrality by managing every single battery, and promoting a rebuild, reduce, and recycle variation of the 3Rs.
May 12	Solterra (new model)	Subaru	Packed with new distinctly BEV value and Subaru-only value, this first Subaru global BEV is environmentally friendly while also offering a level of practicality that makes it as confident a choice as any other Subaru model. The independent front and rear motor-driven AWD takes advantage of the high response and precision of the motors to create an AWD system for a new era. The control systems have been enhanced with Grip Control, which automatically maintains a constant vehicle speed (between approximately 2 and 10 km/h) when driving on rough roads and enables the driver to focus on steering. The e-Subaru Global Platform, a dedicated BEV platform jointly developed with Toyota, offers a high level of stability and controllability, and a linear response to driver steering operations to realize true Subaru dynamic high quality driving.
May 27	Stepwgn (complete redesign)	Honda	This model was developed under the #pleasantlifestyle grand concept with the goal of becoming a source of lifestyle enrichment that matches the day-to-day of the customer. It offers a space to relax in the form of the largest interior in the history of Honda vehicles in Japan, and strives for interior comfort where every seat provides a living room-like comfortable experience. In terms of reliability in motion, it offers a field of view that makes it easy to get a sense of the vehicle, as well as a design that reduces the likelihood of car sickness, in a bid to create an interior where everyone in the vehicle feels safe. This model also features the latest driving safety support functions as standard equipment. The lineup features two variants: a hybrid model equipped with the proprietary Honda e:HEV two-motor hybrid system, which uses a variety of drive modes centered around motor driving as appropriate, and the gasoline vehicle variant equipped with the 1.5 -liter direct injection VTEC turbocharged engine that offers enhanced quietness and higher power.

Table 8 Main Product Technology Trends in Ordinary and Light-Duty Automobiles Produced in Japan in 2022 (cont.)

Release date	Type	Manufacturer	Major details
July 1	Civic e:HEV (hybrid system added)	Honda	This model seeks to offer new value in the form of the thrilling driving produced by the enhanced sports e:HEV. The newly adopted direct injection system injects fuel directly into the cylinders, resulting in fuel combustion without waste that raises the torque and expanded the engine mode driving range compared to the original e:HEV 2.0 -liter engine. The intelligent power unit (IPU) uses new low-height cells in the embedded lithium-ion battery, further increasing the energy density per weight of the battery module and raising the efficiency of the package. The know-how acquired through electric-powered vehicle development was also leveraged to expand the operating region while taking the service life of the battery into account.
July 25	X-Trail (complete redesign)	Nissan	The second generation e-Power system equipped with high power motors realizes dynamic and smooth driving. At the same time, the use of a VC turbocharged variable compression engine keeps engine speed down from the normal range up to acceleration, achieving impressive quietness. The model is also equipped with the e-4 ORCE electric four-wheel drive control technology that integrates electrification technology, four-wheel drive control technology, and chassis control technology. The two front and rear high power motors and integrated control of the left and right brakes optimize the driving force of the four wheels to not only enable the vehicle to manifest its rough road capabilities on snowy or hilly roads, but also offers exciting driving in any situation, including day-to-day driving in the suburbs, providing pleasant ride comfort to all occupants.
August 8	Landy (complete redesign)	Suzuki	(OEM of the Toyota Noah) The overall length of 4,695 mm and overall width of 1,730 mm body dimensions and the diversity of seat arrangements made possible by the long slide of the second row seats creates a spacious interior offering a high degree of freedom. The model offers excellent ease-of-use through a full suite of systems that include hands-free dual power sliding doors (with one-touch switch and jam protection) on both sides that users can open or close simply by placing their foot under the front door sensor, as well as a free-stop liftgate that can be stopped at any point while opening or closing. The powertrain is available in both a hybrid and gasoline variant to meet the broad expectations of customers.
August 23	Sienta (complete redesign)	Toyota	This model further polishes the easy to use interior of the first generation while remaining an appealing easy-to-handle 5 -series license plate vehicle that features the latest safety systems and low fuel consumption, and is offered at an affordable price. While retaining its identity as a 5 -series license plate vehicle emphasizing maneuverability in day-to-day life, this new variant combines an additional 20 mm of interior height (compared to previous models), a low horizontal tone belt line, and styling that makes the side windows stand out to create an interior with a wide-open feel. The interior comfort of the second row has been enhanced with a class-leading maximum front to rear couple distance of 1,000 mm (80 mm more than previous models). Packages from everyday shopping can conveniently be set at the occupants' feet. The high efficiency of the hybrid system that uses a 1.5 -liter Dynamic Force engine results in high-level driving that provides both superior ride comfort and excellent fuel consumption performance.
September 1	Crown Crossover (complete redesign)	Toyota	The 2.4 -liter Dual Boost Hybrid System, an inline 4 -cylinder turbocharged engine generating powerful torque from low engine speeds that is directly linked to the motors and combines the eAxle high power water-cooled motor at the rear with a newly developed bipolar nickel hydrogen battery that decreases resistance in the battery and generates high power, is used to achieve superb stability & controllability through full-torque driving and the distribution of driving force to all four wheels.
September 15	CX-60 (new model)	Mazda	In addition to the smooth and powerful driving provided by the vertical platform and high power powertrain, this totally new SUV seeks to deliver an exterior and interior design grounded in Japanese sensibility and aesthetics along with the latest in environmental and safety performance, as well as a high level of confidence. This is the first model equipped with Driver Emergency Assist (DEA), an advanced driver assistance technology that detects driver emergencies, prevents accidents, and mitigates damage. The Driver Emergency Assist system consists of safety technologies that combine the Driver Monitoring system, which uses an infrared camera to monitor the driver and very precisely detect fatigue or drowsiness based on eye closure or other factors, as well as identify sudden changes in driver health condition from behaviors such as changes in posture or head position. The system not only automatically slows down and stops the vehicle, but also transmits an emergency notification, when it determines that the driver is unable to continue driving due to a loss of consciousness caused by a brain, low blood sugar, or other disorder such as epilepsy or a cardio- or cerebrovascular condition. This model also features the Mazda Driver Personalization System, which relies on the automatic driving position guide, which facilitates safe driving and contributes to mitigating occupant damage in a collision, to automatically adjust the seat, steering wheel, and outer mirrors, helping any driver sit in the recommended driving position.
October 31	Harrier (PHEV model added)	Toyota	A plug-in hybrid model equipped with a high capacity lithium-ion battery has been added to the lineup. In addition to boosting the driving performance through motors, this model achieves excellent stability & controllability thanks to smooth acceleration and a low center of gravity.
November 11	Lexus(new model)	Subaru	(OEM of the Daihatsu Rocky) This first Subaru light-duty SUV allows users to enjoy driving with confidence in any situation, from everyday errands around town to short excursions. The latest Smart Assist and lightweight, high durability body offer superb safety performance.
November 18	Lexus RX (complete redesign)	Toyota	Enhancements such as the addition of a PHEV model have resulted in a powertrain lineup that contributes to realizing a carbon neutral society and meets a variety of customer needs while remaining in-tune with the increasingly diversifying customer needs and lifestyles. This model is equipped with the Direct 4 four-wheel drive system that supports driving fully in line with the driver's intent, the newly developed 2.4 -liter T-HEV hybrid system equipped with the eAxle high power motor at the rear, the Vehicle Braking Posture Control system that controls vehicle posture while driving, and Dynamic Rear Steering (DRS) system for the rear wheel steering angle which provides high maneuverability and a sense of confidence at high speeds. The vehicle also features the enhanced Lexus Safety System+ designed to achieve zero traffic accident casualties, as well as cutting-edge parking support.

Table 8 Main Product Technology Trends in Ordinary and Light-Duty Automobiles Produced in Japan in 2022 (cont.)

Release date	Type	Manufacturer	Major details
December 22	Serena (complete redesign)	Nissan	The next step in the evolution of this minivan designed to enable customers to fully enjoy precious time spent with family by maximizing comfort during travel, this model provides state-of-the-art technologies, and offering an extensive variety of functions while retaining its spacious interior and convenience. Using the second generation e-Power system enabled the installation of the world's first energy management technology that coordinates with the navigation system to control the timing of engine starts, reducing their frequency and contributing to greater quietness. When approaching a registered parking location, the touch of a button suffices to automatically control the steering wheel, accelerator, brakes, and gear shifting operations, as well as the parking brake. This minivan also features the ProPilot Remote Park system, which has a memory function that makes it possible to remotely move the car in or out of a parking spot, making it easy to get in or out of the vehicle, or to handle luggage, in narrow spaces.

Table 9 Product Technology Trends for Passenger Cars In 2022

Release date	Type	Manufacturer	Major details
June 16	Nissan Sakura (new model)	Nissan	This represents a completely new electric mini-vehicle that runs on 100 % electric power. In conjunction with the hallmark ease of handling of mini-vehicles, this model offers quietness only achievable in electric vehicles along with smooth and powerful acceleration. The optimization of the motor structure achieves the highest level of quietness in a mini-vehicle. This model makes electric vehicles seem more accessible thanks to a cruising range that completely covers day-to-day driving such as commuting or shopping, a spacious interior space, and a very affordable price.
June 16	eK Cross EV (BEV model added)	Mitsubishi	This model complements a spacious interior and ease-of-use on part with the non-EV variants with the smooth and powerful driving, impressive quietness, and superb ride comfort unique to EVs. In addition, it fuses comfort and convenience through advanced driving assistance functions and connected technologies. Those functions and technologies reduce driver burden and offer safe, confident, and pleasant driving. This vehicle also features the MI-Pilot Parking system that supports getting in or out of parking spots smoothly.
July 13	Move Canbus (complete redesign)	Daihatsu	This model comes in two variants, the sleek and elegant Stripes new Canbus and the Theory projecting a calm and elegant vision, which create different worlds while still inheriting the charm of the first generation. The application of the DNGA has increased fuel efficiency (WLTC mode) through improvements such as reducing the vehicle body weight by approximately 50 kg. Both ease of driving and ride comfort quality have been improved to erase any uneasiness or concerns customers might feel about driving.

purposely limited scope of new models (including the adoption of new power trains or new vehicle body structures) and complete redesigns among the ordinary, light-duty, and mini-vehicles introduced to the Japanese market by Japanese automakers in 2022.

As seen in the tables, 16 of the 19 models are examples of adding new BEV or hybrid variations. Overall, it was a year of advances in BEVs and other forms of electrification. Other examples included automakers introducing BEVs for the first time, as well as the launch of jointly developed models.

3. 1. Environmental Technologies

The goal of achieving carbon neutrality has set high expectations worldwide for BEVs, and the EU and the U.S. government are at the forefront of efforts to encourage a transition to BEVs via subsidies as well as tighter CO_2 and emissions regulations.

The Japanese market is in the process of transitioning to power generation using renewable energy sources and building a charging infrastructure. The gradual introduction of EV models, the expansion of hybrid technologies, and advances in internal combustion engines form the basis of efforts to reduce CO_2 in a practical and sustainable manner.

In addition to improvements in battery performance, environmental technologies feature improvements in aerodynamic performance and the adoption of heat pump air conditioners and radiation heaters as part of technologies to conserve energy while driving. Automakers continued to introduce models offering value unique to electric-powered vehicles and EVs, including electric drive control technologies that capitalize on the distinctive motor quietness and responsiveness/high accuracy feature of such vehicles, and broad, flat interior spaces built on dedicated platforms.

As part of the period of transition to BEVs or of preparation to move to renewable energies, technologies that raise engine combustion efficiency and exhaust emissions

performance, as well as dedicated hybrid technologies that further increase the quietness of the engine during power generation, have also been introduced.

3. 2. Safety Technologies

All automakers are continuing to intensify the development of safety technologies and deploying them in more products as they work toward zero fatalities from traffic accidents.

Collisions with cyclists have been added to the damage mitigation brake test in the Japan New Car Assessment Program (JNCAP), and automakers are expanding the scope of other objects detected by their safety systems beyond just bicycles.

Rather than only striving for fully autonomous driving, automotive technologies are used and expanded from a practical standpoint to bring improvements in areas such as vehicle safety, measures to alleviate congestion, user friendliness, and reducing driver burden.

Examples involving active safety include the introduction of technologies that automatically avoid coming too close to nearby vehicles or pedestrians and support safe driving, as well as of technologies that detect drowsiness, sudden changes in driver health conditions, or other driver emergencies, and automatically pull the vehicle over and send an emergency notification.

3. 3. Other Technologies

In the field of software, vehicles are being equipped with systems capable of updating to the latest version of on-board software even after purchase through over the air (OTA) or other forms of communication, and the installation of an on-board environment that makes the car a Wi-Fi spot is becoming more common.

Technology that builds on the sensors in advanced safety technologies and on vehicle control technology to facilitate parking by enabling remote vehicle operation via a smartphone has been introduced.

Elsewhere, advances have also been observed in technologies that enhance the traditional appeal of cars, such as technologies that achieve wide interior spaces or quietness.

Design Trends

1 Overview of Design Trends

1. 1. Crossover Trends

It goes without saying that global crossover trends in 2022 centered around SUVs. Users all over the world appreciate both their adaptability to a variety of situations, and the appeal of expressing their own lifestyle. Crossovers blend the appeal of various categories into SUVs, and are becoming increasingly diverse. Key words that stood out in expressing the new product design direction taken by automakers over the past year include combining SUV-like “power” with “sportiness” and “elegance”, as well as “simple”, “modern” and other expressions setting a clear and simple tone. The details are presented below.

1. 2. Designs Straddling Tradition and Innovation

In design, conveying innovative messages in a straightforward manner is critical. For the overall form, this is exemplified by the continuous cabin and body monoform seen in the Mercedes-Benz EQS (Fig. 1) and Toyota Prius (Fig. 2). Similarly, the Hyundai Ioniq 5 (Fig. 3) and Kia EV6 (Fig. 4) BEVs feature a frame unlike those of past internal combustion engine (ICE) vehicles, presenting

Fig. 1 Mercedes-Benz EQS

Fig. 2 Toyota Prius

Fig. 3 Hyundai Ioniq 5

Fig. 4 Kia EV6

Fig. 5 Ferrari Purosangue

Fig. 6 Lotus Eletre

fresh forms that embody their respective brand messages and has earned them Car of the Year (COTY) title or design awards in many places. Among accessories, lamps are featuring an increasing number of light emitting motifs providing a diversity of lighting patterns which, in conjunction with plastic components providing a high level of form flexibility, supports novelty and innovation in designs.

At the same time, traditional sports car makers have announced crossovers such as the Ferrari Purosangue (Fig. 5) or the Lotus Eletre (Fig. 6). Both vehicles share the ability to identify the intersection of traditional sports car appeal and the needs of the time and achieve a high quality form that does not sacrifice their brand image. In this age of transformation typified by CASE, all automakers are looking into creating value through various design approaches to broaden the options of existing value and achieve novelty in the context of their own situation as they battle for survival.

2 Trends in Japanese Cars

2. 1. SUVs and Crossover SUVs

Many crossover SUVs were announced in the Japanese market as well. The Toyota Crown (Fig. 7) moved

Fig. 7 Toyota Crown

Fig. 8 Lexus LX

Fig. 9 Lexus RX

Fig. 10 Lexus NX

Fig. 11 Lexus RZ

from its sedan roots to a series of global models centered on crossover SUVs. A new simple and sporty look also replaced its previous highly dignified face. Lexus revamped the LX (Fig. 8), RX (Fig. 9), and NX (Fig. 10) giving them, along with the RZ BEV (Fig. 11), a shared

sharp and stylish expression of form that sends a unified message.

The Nissan X-Trail (Fig. 12) retains the flavor of traditional SUVs while transitioning into a new era by applying novelty to the design elements of its accessories. The Mazda CX-60 (Fig. 13) pursues premium SUV value through its traditional ICE front proportions. The Honda ZR-V (Fig. 14) and the Subaru Crosstrek (Fig. 15) have a relatively low overall height that brings out a high sense of quality and fun that is focused on day-to-day use.

These models all share large wheels and a protruding fender that emphasizes the surrounding chassis. The form of the fender originating from the wheels is emphasized by a part known as a cladding, and the way the fender and body are fused is the source of diverse expressions of form such as a dynamic sense of speed, or an elegant luster.

Fig. 12 Nissan X-Trail

Fig. 13 Mazda CX-60

Fig. 14 Honda ZR-V

Fig. 15 Subaru Crosstrek

2. 2. Evolution of Unique Japanese Minivan Culture

In 2022, Toyota, Nissan, and Honda revamped their C-segment high-roof wagons. These vehicles increase space efficiency while also skillfully combining elements of luxury vehicle style and aerodynamics, exhibiting status and attractive ornamentation, and offering a full array of features stimulating the desire to own one. Each and every automaker is stepping up its game in expressing such features. The face of the Toyota Noah and Voxy (Figs. 16 and 17) inherits the formidable presence of the higher grades, while the details also project a sense of luxury. The Nissan Serena (Fig. 18) rearranges commonplace elements to bring out an out-of-the-ordinary freshness, and exhibits ideas that step outside everyday conventions. The modern box expression with simple ornamentation of the Honda Stepwgn (Fig. 19) takes an approach that removes the sense of day-to-day. These

Fig. 16 Toyota Noah

Fig. 17 Toyota Voxy

Fig. 18 Nissan Serena

Fig. 19 Honda Stepwgn

Fig. 20 Toyota Sienta

Fig. 21 Suzuki Spacia Base

Fig. 22 Daihatsu Move Canbus

examples illustrate how richness of expression is broadening. The B-segment Toyota Sienta (Fig. 20) relies on a rounded form and casual graphics to express the joy of day-to-day life rather than space efficiency or status.

2. 3. Unique Japanese Automobile Culture Demonstrated by Mini-Vehicles

If you defined the C-segment high-roof wagon as a moving living room, the mini-vehicle wagon would be a moving private booth. They offer users the possibility of creating their own world and enjoying it. The Suzuki Spacia Base (Fig. 21) is a model that can be adapted to hobby or work purposes and emphasizes a secret base-like gadget feel that is intended to be customized. In contrast, the Daihatsu Move Canbus (Fig. 22) evokes a lady's private rooms through its charming ladylike kindness

Fig. 23 Nissan Sakura

Fig. 24 Mitsubishi eK Cross EV

and stylish two tone colors. The Nissan Sakura (Fig. 23) and Mitsubishi eK Cross EV (Fig. 24) represent new BEV ideas in the mini-vehicle space. Each builds on the same platform to express its respective brand by incorporating the design themes and elements of the brand's high grade models.

3 Overview of Interior Design

3. 1. Cockpit or Living Room?

The interior of automobiles is both a cockpit to enjoy driving and a room to make movement comfortable. Advances in information technologies and electronic devices are bringing automated driving closer to reality, and the fun of driving is being complemented with a growing enjoyment of entertainment and communication. In addition, some models, such as the Suzuki Spacia Base (Fig. 25), offer flexible interiors intended to accommodate cabin use purposes other than driving.

3. 2. Spatial Configuration and Layout of Visibility Systems

The expression of comfortable movement spaces is trending toward wider interiors, with the use of a horizontal instrument panel, as seen in the Crown (Fig. 26) for example, is a typical approach. A layout that sets the gauge cluster in front of the driver and places a large display in the instrument panel has become mainstream. Designs relying on a cockpit enclosing the driver seen in sports cars and other models are now in the minority. The use of displays without a cover over the gauges, as seen in the Toyota Prius (Fig. 27) and the Nissan Serena (Fig. 28) is becoming more common.

Fig. 25 Suzuki Spacia Base

Fig. 26 Toyota Crown

Fig. 27 Toyota Prius

Fig. 28 Nissan Serena

3. 3. Evolution of Operating Devices

The transition from mechanical to electric devices is bringing about advances that are not limited to the conventional functional purpose of improving space efficiency and operability, but also extend to design elements that appeal to sensibility. Examples include providing feedback through a soft tactile feel or finely tuned click sensation, or through pleasant audio guidance.

3. 4. Color and Material Coordination

Luxurious modern tastes have undoubtedly become a trend. Although tempered by a range of expressions based on brand image conformity, model grades, or other factors, presentations of harmonious worldviews, such as the focus on Japanese aesthetics in the Mazda CX-60 (Fig. 29), are becoming more prevalent.

Fig. 29 Mazda CX-60

4 Concept Cars

The Audi sphere concept (Fig. 30) aimed at realizing the entirety of CASE presents visionary concept cars that showcase the future of the brand. The stylish design supported by a low profile elegant form and large wheels highlights an avant-garde futuristic view. Experimental concept cars intended to gauge market response include examples of pursuing the appeal of out-of-the-ordinary SUVs such as the Dacia Manifesto (Fig. 31). The Toyota bZ Compact SUV Concept (Fig. 32) represents a proto-

Fig. 30 Audi Sphere Concept

Fig. 31 Dacia Manifesto

Fig. 32 Toyota bZ Compact SUV Concept

typical teaser concept car. The consistent expression of form of the Toyota series of crossover models hints at the near future of Toyota BEVs.

5 Conclusion–Prospects for Future Automobile Design

With society as a whole coming to a consensus on embracing diversity, a corresponding major shift in people's perceptions, as well as significant changes to lifestyles and the social environment, are likely to occur. Envisioning this new age, creating a new image that resonates with many people, and inspiring high hope in society, represent both the expectation placed on design, and its mission. The vision of the future drawn by design should, hopefully, connect to dreams and aspirations that exceed the perception of people who will enjoy greater freedom, and bring them happiness via their day-to-day life.

Body Structures

1 Trends in Body Technologies

The entire world is engaged in curbing global warming to preserve biodiversity and realize a sustainable society. Japan has set the goal of achieving carbon neutrality by 2050, a year also set as the deadline for that same purpose by 154 countries and one region as of the conclusion of COP 26 in November 2021. With respect to automobiles, Japan has declared that 100% of new vehicles sold must be electric vehicles by 2035. The Council of the European Union has adopted a resolution to cut 100% of CO_2 emissions from new vehicles and new light-duty commercial vehicles starting in 2035. Automakers have also set electric vehicle targets in response to those policies (Fig. 1).

Nevertheless, popularizing battery electric vehicles (BEVs), which emit zero CO_2 while driving, requires addressing issues such as the supply of electricity, establishing an infrastructure, and CO_2 emissions during production. At the same time, means of achieving carbon neutrality are not limited to electric vehicles and also include fuel cell vehicles, synthetic fuel engine vehicles, and hydrogen engine vehicles. Electrification is anticipated to continue to expand, and it will be necessary to keep a close eye on adoption rate-related policies and market trends in various countries. In vehicle bodies, weight reduction that helps reduce fuel consumption or electricity consumption, the electric vehicle equivalent, and ensuring that stability and controllability, passive safety, and NVH remain independent of the powertrain, are crucial issues.

This section presents the vehicle body technologies observed in models sold in 2022 in the context of the above factors.

2 Dedicated EV Platform

There are many differences between BEVs and ICE vehicles, including a downsized powertrain and the absence of a fuel tank and exhaust system. Therefore, the pace of efforts to revamp the platforms (P/Fs in the remainder of this article), develop dedicated EV P/Fs, and share them between companies, is picking up.

Toyota has jointly developed the dedicated EV e-TNGA (Toyota New Global Architecture) P/F with Subaru.

	Toyota	Honda	Nissan	Mazda	Mitsubishi
2050	Zero CO_2 emissions over the entire lifecycle	Achieve carbon neutrality	Realize carbon neutrality over the entire lifecycle, including business activities		
2040		100% BEVs/FCVs on a global scale			
2030	Worldwide sales of 3.5 million EVs and FCVs Introduce 30 new EV models	Electric-powered vehicle ratio of 100% (20% BEVs/FCVs)	Electric-powered vehicle ratio of 50% Introduce 23 electric-powered models, including 15 EV models, and invest approximately 2 trillion yen over the next five years	Make all models electric-powered (BEV ratio of 25%)	Make all models electric-powered

Fig. 1 Automaker Carbon Neutrality Targets (as of June 2022)

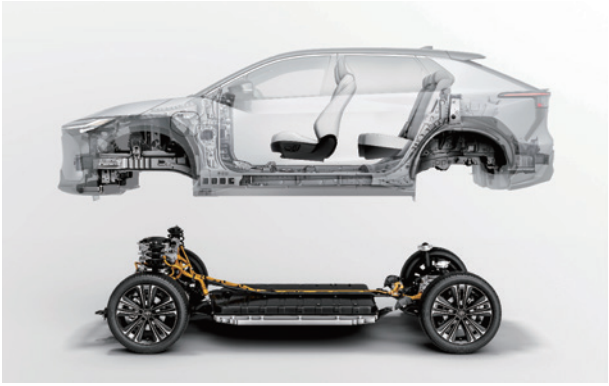

Fig. 2 Toyota bZ4X Platform

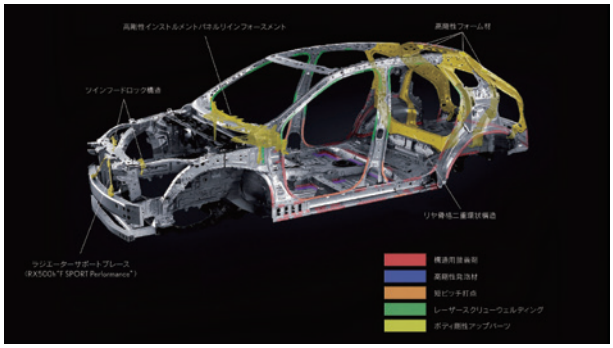

Fig. 3 Lexus RX Technologies to Improve Body Rigidity

The Toyota bZ4X and Subaru Solterra launched in May 2022 are built on this platform.

Renault, Nissan, and Mitsubishi are planning to introduce 35 new EV models built on five dedicated EV P/Fs by 2030. Of those, the EV platform known as the Common Module Family (CMF) serves as the basis for the Nissan Ariya and the Renault Mégane E-Tech.

Outside Japan, Volkswagen has developed the modular electric drive matrix (MEB) platform, and is sharing it with the Ford European market EVs.

General Motors has developed the shared Ultium platform for its Chevrolet and GMC brands, and launched the GMC Hummer EV.

Designing the vehicle structure from scratch makes it possible to realize packages and styling that build on the advantages of BEVs. At the same time, sharing platforms across models and between automakers is expected to keep development costs down and increase development efficiency. As BEVs become more common, many eyes will turn to the types of P/Fs automakers develop and deploy, and the products they bring to the market.

3 Technological Trends Concerning Performance Requirements

3. 1. Stability and Controllability

Stability and controllability tie directly into the joy of controlling the vehicle as desired, offer passengers peace of mind, and contribute to the precision of driving assistance functions. In addition, the vehicle body gets twisted and bent by inputs from the wheels or changes in vehicle behavior. Consequently, there is a need to raise body rigidity and suppress deformation, as well as to apply control.

One method of increasing rigidity is to reinforce joint strength. In the Lexus RX, body rigidity was increased by applying laser welding or structural adhesive to the frame joints and adopting narrow pitch spot welding technology, which enables welding using short pitches (Fig. 3). The Honda ZR-V uses structural adhesive primarily around the floor, and improves the dynamic rigidity feel by joining surfaces over a wide area. Development also extended beyond numerical rigidity values to focus on the balance between stiffness and flexibility.

In BEVs, the batteries and their protective casing are under the floor, and manufacturers have started to leverage this feature for stability and controllability. Having battery casings improves torsional rigidity, one of the metrics used in stability and controllability, by 30 to 60% over having none.

The use of adhesives and other basic technologies, optimal rigidity balance, and functional joining with peripheral parts is anticipated to help achieve both greater stability and controllability while simultaneously reducing weight.

3. 2. Passive Safety

The active safety technologies that prevent accidents from happening are constantly evolving, as are the passive safety technologies that protect occupants if an accident does occur.

To also protect the other vehicle in a collision between vehicles, the Mazda CX-60 features a perimeter beam ahead of the subframe at the front of the vehicle. Widening that beam along with the bumper reinforcement maximizes the opportunity for the vehicle to absorb both its own energy and that of the other vehicle.

In BEVs, the placement of batteries under the floor requires protecting them from side impacts. At the same time, installing many batteries to increase cruising range decreases the amount of crash space, which in turn calls

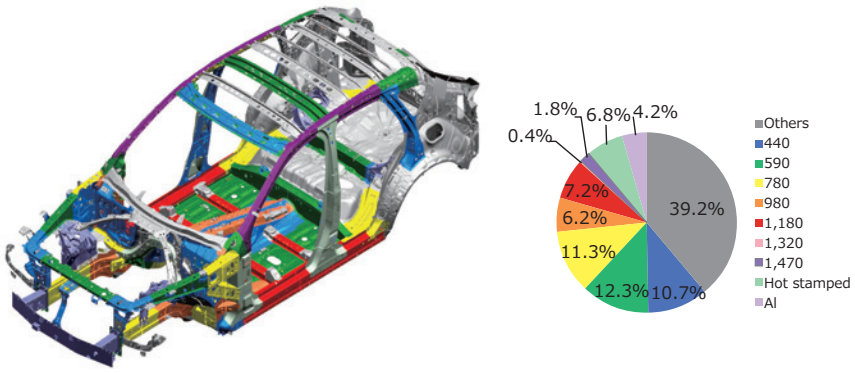

Fig. 4 Mazda CX-60 High-Tensile Strength Material Use Ratio

for higher yield strength and leads to increasing vehicle weight. To address this issue, the Toyota bZ4X, Subaru Solterra, and Nissan Ariya simultaneously protect the battery and secure enough space for it by absorbing side impact loads not just with the vehicle body, but also with the battery case.

4 Vehicle Body Technologies

4. 1. Steel Sheets

Steel sheets constitute the mainstream part for vehicle bodies, and hot stamped material obtained by heating steel sheets is increasingly adopted to reduce weight by making the sheets tinner while raising tensile strength to improve safety in a collision.

The body of the Mazda CX-60 uses 1,800 MPa class hot stamped material and 1,470 MPa class cold high tensile strength steel sheets, achieving a breakthrough 32% mass reduction in conjunction with other high tensile strength materials while securing occupant survival space (Fig. 4). The Lexus RX became the world's first vehicle to use 2,000 MPa class hot-stamped material in the B pillar. The Nissan Sakura adopts more hot-stamped material, increasing the proportion of 980 MPa and higher class high tensile steel sheets to 28% from the 16% in the Dayz to mount the battery and ensure collision performance. It also protects both occupants and the battery by encasing zones requiring protection with high tensile strength steel sheets or hot-stamped material while using 590 MPa or lower class sheets in energy absorbing zones.

The Toyota bZ4X and Subaru Solterra use 980 MPa or higher class high tensile strength steel sheets and hot-stamped material in 24% of the vehicle body, reducing weight by 11%.

However, although hot-stamped materials have high strength and superior formability, hot stamping requires more thermal energy than cold stamping and generally emits greater quantities of CO_2. Reducing the number of parts, streamlining manufacturing processes, and using the right material in the right location is anticipated to reduce CO_2 emissions. Consequently, design that takes those elements into account will become increasingly important.

4. 2. Aluminum

Aluminum excels in the areas of vehicle body weight reduction and flexibility of design. However, challenges such as the higher cost of the base metal compared to steel sheets and the facility investment required to introduce joining methods that differ from the spot welding commonly used for steel sheets have limited the adoption of aluminum in vehicle bodies.

The Mazda CX-60 is the first Mazda vehicle body to use die cast aluminum in the top of the front and rear dampers, thereby achieving the intended balance between rigidity and weight reduction while also reducing the number of parts. The use of de cast aluminum in the top of the dampers can also be seen in other vehicles, such as the Lexus LC, and is becoming more common in high-end models.

The Tesla Model Y features large die cast aluminum sheets at the front and rear. Building the section that consisted of 171 parts in the Model 3 with just two parts decreased the number of joining points between parts and streamlined the production process.

This illustrate how designing a structure that takes advantage of the characteristics of the material and manufacturing methods rather than simply using it as a substitute for steel sheets is crucial to the adoption of aluminum.

The Toyota bZ4X and Subaru Solterra BEVs use

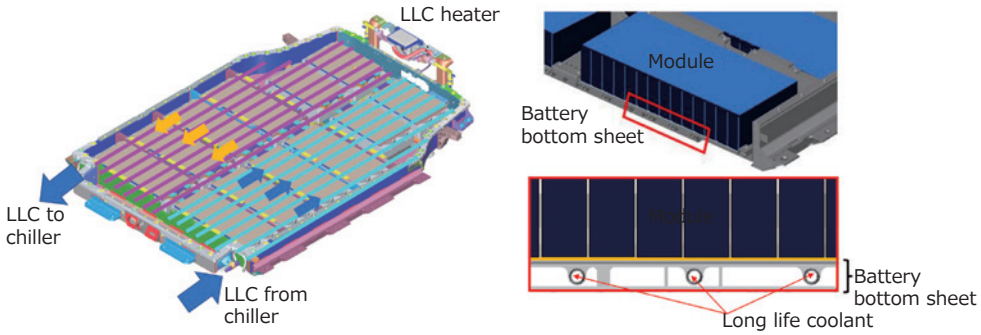

Fig. 5 Cross-Section of the Battery Bottom Sheet with Long Life Coolant Flow Paths in the Nissan Ariya

6,000-series aluminum member extrusions next to the battery case to protect the battery in an impact. The use of aluminum for the battery case is common, and the mainstream approach consists of a structure that relies on aluminum extrusions to form cross members around and inside the case, and uses a sheet for the cover. The battery case of the Nissan Ariya uses aluminum extrusions not only around the case and in cross members, but also in the bottom sheet. This approach makes it possible for the bottom sheet containing the long life coolant flow path mechanism to remain thin and constitutes a structure that leverages the characteristics of aluminum extrusions (Fig. 5).

However, processing aluminum from new base metal emits three to four times as much CO_2 during manufacturing as processing steel sheets. This is leading to efforts to cut down on CO_2 emissions through the use of recycled base metal, as well as of renewable energy during manufacturing. With respect to relying on renewable energy, joint efforts by Nissan and Kobe Steel, Ltd. have achieved an approximately 50% reduction in CO_2 emissions during base metal manufacturing by applying electrolysis using only solar power-generated electricity and making use of the resulting aluminum base metal.

Calls to reduce not only driving CO_2 emissions through weight reduction, but also CO_2 emissions over the entire life cycle assessment, including manufacturing, will intensify.

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