EFFORTS REGARDING PRODUCT AND TECHNOLOGY DEVELOPMENT

In 2017, Mazda announced "Sustainable Zoom-Zoom 2030" (see pp. 8-12) in light of the rapid changes taking place in the automotive industry around the world. This updated vision for technology development takes a long-term perspective and sets out how Mazda will use driving pleasure, the fundamental appeal of the automobile, to help solve issues facing people, the earth and society. Mazda believes its mission is to bring about a beautiful earth and to enrich people's lives as well as society. The Company will continue to seek ways to inspire people through the value found in cars. In terms of the environment, "Sustainable Zoom-Zoom 2030" demonstrates Mazda's determination to use conservation initiatives to help create a sustainable future in which people and cars can coexist with a bountiful, beautiful earth.

Energy-and Global-Warming-Related Issues

Approach to Product Environmental Performance

As vehicle ownership continues to expand around the world, automobile manufacturers must redouble their efforts to achieve cleaner exhaust emissions, and improve fuel economy in order to cut CO_2 emissions and help reduce the world's dependence on increasingly scarce fossil fuels. Mazda considers it necessary to develop a multi-solution approach to automobile-related environmental issues that takes into account various factors such as regional characteristics, vehicle characteristics and types of fuel.

Addressing Global Warming a

Mazda sees reducing emissions of CO_2 and other greenhouse gases over the vehicle's entire lifecycle — including manufacturing, use and disposal — as one of its top priorities and a duty of automotive industry. The Company wants to maximize its contribution by considering not only "tank-to-wheel" emissions that occur while driving but also "well-to-wheel" emissions, including fuel extraction, refining and power generation (well-to-tank). Offering a number of powertrain options in consideration of each region's energy sources and power generation methods will allow Mazda to make the optimum contribution to CO_2 emissions reductions by region. In August 2017, Mazda set a goal of reducing corporate average "well-to-wheel" CO_2 emissions to 50% of 2010 levels by 2030, with a view to achieving a 90% cut by 2050.

Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is a method for calculating and evaluating the environmental influence of vehicles across their entire life cycle through the purchase of materials, manufacture, use, recycling, and final disposal. Since 2009, Mazda has adopted LCA as a means of determining the time required to reduce the environmental impact of vehicles in their life cycle, and has been actively working to reduce the environmental impact at each stage of the life cycle. The Company is also promoting evaluation of the practicability and reliability of new technologies for environmental performance in compliance with the methods specified in the international standards (ISO14040 and ISO14044).

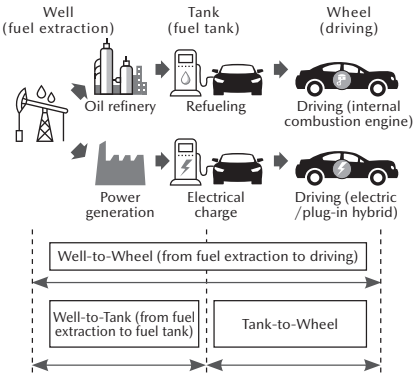
Multi-solution Oriented Technology Development through Effective Use of LCA b c

Automotive power sources, the energy situation, and the composition of power sources differ from region to region. Mazda has been promoting the development of various technologies to offer the right solution to each region. In FY March 2019, the Company assessed the life cycle CO_2 emissions from internal combustion engine vehicles and electric vehicles (EVs) in five regions of the world. The results revealed that the significance of CO_2 emissions from internal combustion engine vehicles and EVs during their life cycles depends on the electric power supply status, fuel/electrical power cost, total mileage, and other factors in each region. In FY March 2020, these LCA results were compiled into academic papers and presented at academic conferences.

a The "Well-to-Wheel" Perspective

Make efforts to reduce CO_2 emissions from the perspective of "well-to-wheel," with the aim of reducing emissions over a vehicle's entire lifecycle.

Conceptual diagram of Well-to-Wheel*



∗ Where fossil fuel is extracted and used to drive a vehicle.

b Conference presentation/Publication of paper on Mazda's LCA

Conference presentation:

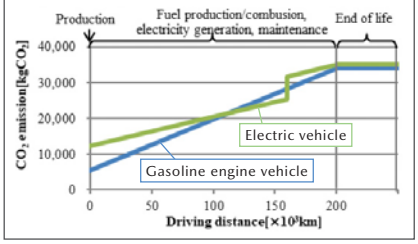
The 9th International Conference on Life Cycle Management (August 2019)
Subject: Estimation of CO_2 Emissions of Internal Combustion Engine Vehicle and Battery Electric Vehicle Using LCA

Publication of academic paper:

Sustainability magazine, 2019, Volume 11, Issue 9, p.2690
Subject: "Estimation of CO_2 Emissions of Internal Combustion Engine Vehicle and Battery Electric Vehicle Using LCA"
https://doi.org/10.3390/su11092690

c An example of a comparison between an internal combustion engine vehicle and an electric vehicle in terms of CO_2 emissions (in Japan)

Until the travel distance reaches approximately 110 thousand km, the internal combustion engine vehicle emits less CO_2 than the electric vehicle; however, this magnitude relationship reverses when the travel distance exceeds the above distance. (However, if the battery of the electric vehicle is replaced once at a travel distance of 160 thousand km, the internal combustion engine vehicle emits less CO_2.)

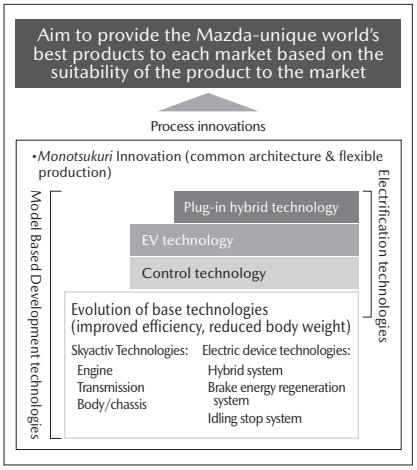


The Building-Block Strategy

d e

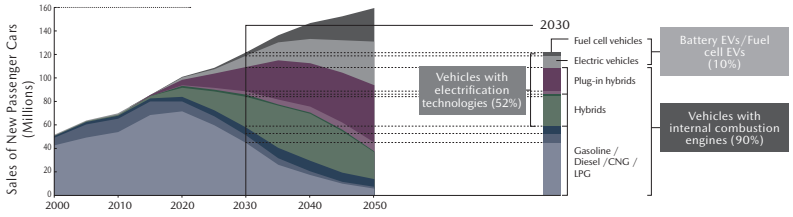
Mazda adopts the Building-Block Strategy to realize its goal of reducing CO_2 emissions and raising the average fuel economy of Mazda vehicles sold worldwide. Given the internal combustion engine is forecast to remain a principle propulsion technology in cars worldwide for many years to come, the Company thinks it important to continue efforts to perfect the technology. At the same time, the Building Block Strategy also calls for the commercial introduction of electric, plug-in and other electrified vehicles (EVs) in consideration of each country or region's energy resources, regulations, power generation methods, infrastructure and so on. Through this Building-Block Strategy and advances in process innovations, such as computer Model-Based Development (see p. 125), and *Monotsukuri* Innovation (see p. 123), Mazda will, despite limited management resources, offer products and technologies that exceed customers' expectations. Mazda plans to start introducing EVs and other electric drive technologies in regions that generate a high ratio of power from clean energy sources or restrict certain vehicle types to reduce air pollution.

d Building-Block Strategy



e Graphic representation of global market share of powertrain technologies

It is expected that the majority of vehicles in the global market will continue to be powered by internal combustion engines, and that such vehicles will contribute the most to CO_2 reduction. (About 90% of the vehicles will be powered by internal combustion engines in 2030.)



Source: IEA/ETP "Energy Technology Perspective2015"

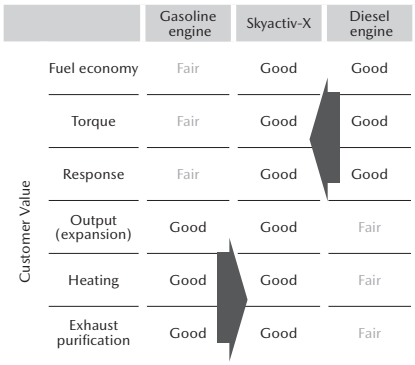
Comprehensive Improvements of Base Technologies by Skyactiv Technology

f

The term Skyactiv Technology covers all Mazda's innovative base technologies. Mazda redesigned these technologies from scratch, enhancing the efficiency of powertrain components, such as the engine and transmission, reducing vehicle body weight, and improving aerodynamics. The number of models featuring Skyactiv Technology has steadily increased since the first Skyactiv-G engine was introduced in 2011 in the Demio (known as Mazda2 overseas). Following the adoption of the technology in the CX-5 in 2012, the number of models that fully incorporate Skyactiv Technology has increased.

Starting in 2019, Mazda has been introducing new-generation technologies, including the Skyactiv-X engine, set to become the world's first commercial gasoline engine to use compression ignition.*1 This unique new-generation engine combines the advantages of gasoline and diesel engines to achieve outstanding environmental performance and uncompromised power and acceleration performance. Mazda will work to increase the number of models equipped with Skyactiv-X while continuing to advance Skyactiv-G and Skyactiv-D, both of which remain highly competitive engines.

f Features of the Skyactiv-X



*1 As of August 2017, according to Mazda data

Improving Fuel Economy

Mazda is working to improve fuel economy in order to help our customers save money and reduce the use of fossil fuels, which is a cause of global warming. Prioritizing improvements in real-world fuel economy, the Company has adopted cylinder deactivation and other technologies that suppress fluctuations in fuel consumption rooted in the way the car is used and environmental factors such as air temperature. Mazda has also employed the mild hybrid system, Mazda M Hybrid, which realizes enhanced fuel efficiency and a pleasant driving experience by maximizing performance of the engine that has been improved in pursuit of ultimate efficiency, through pairing with efficient electrification technologies. Moreover, to provide customers with information on fuel economy that better reflects their real driving environment, the Company was the first automaker in Japan to display WLTC Mode*1 fuel economy figures.

Development of Electrification Technology

After taking into account the appropriate power source for vehicles, the energy situation, the power generation mix, and other factors in each region, Mazda is promoting the development of electrification technology to provide customers in each region with the best solution. In 2030, Mazda will equip all vehicles it produces with electrification technology. In terms of the ratio of power units, internal combustion engine vehicles—including plug-in hybrid vehicles*2 and hybrid vehicles—will account for 95%, while pure electric vehicles will account for 5%. In the development of electrification technology, Mazda follows its unique “human-centered” approach that sets priority on human characteristics and sensibilities in order to make the most of the advantages of electric drives.

Electric Vehicles

Mazda is also committed to developing electric vehicles (EVs) in line with our "Sustainable Zoom-Zoom 2030" vision. Based on the Well-to-Wheel perspective, the Company believes that its electric driving technology for EVs is the optimal solution for a region with sufficient clean energy resources or a region with air pollution control norms. Mazda is promoting the commercialization of EVs full of driving pleasure in these regions. In addition, from the perspective of a vehicle's life cycle, Mazda desires to contribute to substantive reduction of our global environmental impact by installing appropriately sized batteries. At the 46th Tokyo Motor Show (sponsored by the Japan Automobile Manufacturers Association) in October 2019, the Company unveiled its first mass-production EV, the Mazda MX-30, which was released starting in Europe in September, 2020 (see p. 12, 13-16).

g

g MAZDA MX-30

*1 Stands for Worldwide-harmonized Light Vehicles Test Cycle. This is a test cycle based on WLTP (Worldwide-harmonized Light Vehicles Test Procedure)
*2 Hybrid vehicle with a battery that can be charged by household power supply.

TOPICS **Virtual Power Plant Demonstration Experiment for Reuse Technology of Electric Vehicle (EV) Drive Batteries**

Mazda, together with Chugoku Electric Power Co., Inc., and Meidensha Corporation signed a joint research contract to build a stationary-type storage battery system, which reuses driving-force batteries of electric vehicles (EVs), and conduct a demonstration experiment on a virtual power plant (VPP)*1 based on the system. The aim of the demonstration experiment is to verify the possibilities of reusing EV drive-force batteries and utilize them as VPP resources. As part of the experiment, the three companies will build a system to aggregate and control several such batteries and integrate them with other distributed energy sources, including renewable energies, to evaluate the VPP’s responsiveness and the degradation properties of storage batteries, among other aspects. Through this experiment, they intend to gain technologies to optimize the use of renewable energy and control the balance between the power demand and supply. Mazda will continue these undertakings in order to develop technologies that will lead to new services derived from the fusion of vehicle elements and energy, and contribute to the global environment and local communities.

*1 A VPP gathers the numerous dispersed power sources owned by general households or factories, such as renewable energy, EVs, and batteries, and integrates and controls them as if they were a single generation plant.
https://newsroom.mazda.com/ja/publicity/release/2019/201910/191017a.pdf (Japanese only)

Promoting Technology Development for Alternative Fuels

One of the ways Mazda is addressing global warming through its products is by promoting the research and development of technologies compatible with alternative fuels, including biofuels and synthetic fuels, so that countries and regions can use energy sources that suit their circumstances.

Compatibility with Bioethanol and Bioethanol Mixed Fuel

Mixed fuels, which include bioethanol or biodiesel made from plant materials, are attracting attention for their effectiveness in reducing CO_2 emissions. Mazda sells vehicles that are compatible with these fuels.

Efforts for the Spread of Next-generation Automotive Liquid Fuel

Mazda believes that liquid fuel will be an efficient and useful energy source for automobiles and other movable bodies equipped with internal combustion engines even in the future. Notably, next-generation automotive bio-liquid fuels (hereinafter "next-generation biofuels") and other renewable liquid fuels made from microalgae oil and waste edible oil have excellent sustainability since they do not compete with food production and do not cause deforestation, unlike conventional biofuels made from food crops such as corn. For this reason, the Company considers next-generation biofuels to be promising energy sources that can completely replace petroleum-based fuels.

In April 2017, Mazda opened a joint research course called the "Next-generation Automotive Technology Joint Research Course—Algae Energy Creation Laboratory" at a graduate school of Hiroshima University. With support of the Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA) sponsored by the Japan Science and Technology Agency (JST), the Laboratory has been advancing various research projects, including improvement in algae performance using genome editing technology, in order to create renewable bio-liquid fuel from micro algae*1.

Since June 2018, Mazda has participated in the Hiroshima "Your Green Fuel" Project, a demonstration project for next-generation biofuels jointly run by the Hiroshima Council of Automotive Industry-Academia-Government Collaboration and Euglena Co., Ltd. In collaboration with Euglena's Green Oil Japan, the Company strives to construct a model for revitalizing regional areas by establishing an entire biofuel value chain—from material manufacture and supply to the use of carbon-neutral next-generation biofuels—within the Hiroshima area*2.

Mazda has been actively promoting industry-academia- government cooperation and tie-ups between companies to provide technical support for the spread of next-generation biofuels (see pp. 126-130).

h Sales Status of Vehicles Compatible with Bioethanol/Biodiesel Mixed Fuels*1

Japan: Compatible with B5*2 - Mazda2, Mazda3, Mazda6, CX-3, CX-30, CX-5
Thailand: Compatible with E20*3 - Mazda2, CX-8
Compatible with E85*4 - Mazda3, CX-3, CX-30, CX-5

∗1 Subject to variation depending on specifications
∗2 Diesel mixed with 5% biodiesel fuel
∗3 Gasoline mixed with 20% ethanol
∗4 Gasoline mixed with 85% ethanol

*1 https://newsroom.mazda.com/ja/publicity/release/2017/201704/170428c.html (Japanese only)
*2 https://newsroom.mazda.com/ja/publicity/release/2018/201806/180613a.html (Japanese only)

Development of Resin Material for Auto Parts for Weight Reduction

In addition to Skyactiv Technology, which is developed with the whole concept of weight reduction, Mazda actively adopt new technologies for reducing weights in detailed parts. Mazda will continue to pursue weight reduction by using resin, aluminum, ultra-high tensile steel and other materials having both lightness and strength.

Offers a Bumper Which Is One of the Lightest in Its Class

Mazda has developed a new resin material for auto parts that can maintain the same level of rigidity as conventional materials while trimming vehicle weight. Because the new resin enables the manufacture of thinner parts and thus a significant reduction in the amount of material used, when used for front and rear bumpers, this resulted in the reduction of weight by around 20%.

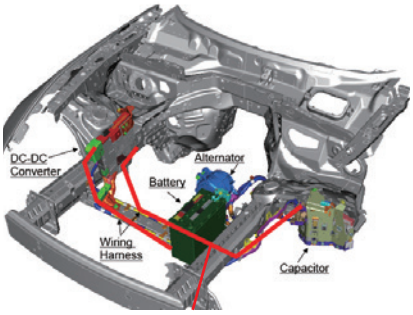
In the manufacturing process, thinner parts have enabled the shortening of cooling time upon shaping and halved the shaping time of bumpers partly due to the utilization of CAE analysis techniques. This resulted in a drastic reduction of the amount of energy used in manufacturing.

Mazda further reduced the specific gravity of this new resin bumper by around 4%. The resultant bumper, one of the lightest in its class*1, has been mounted on a series of new-generation models. The new bumper was attached to the Mazda3 in FY March 2019 and to the CX-30 in FY March 2020.

Development of Light Weight Wiring Harness Using Aluminum Electric Wire i

Mazda has developed a lightweight wiring harness using aluminum electric wire, which enables the Company to achieve vehicle weight reduction while maintaining connection reliability (quality). Since equipping the Roadster/MX-5, launched in 2015, with this lightweight wiring harness, the Company has been increasing the number of models*2 that incorporate the material. In FY March 2020, the lightweight wiring harness was adopted in the CX-30.

i Aluminum electric wire of the Roadster/MX-5
Connection between capacitor and DC-DC converter
Connection between DC-DC converter and battery



Aluminum electric wire

Cleaner Emissions

Cleaner Gas Emissions

Mazda is committed to mitigating air pollution from exhaust gas. To this end, the Company is actively developing low-emission vehicles, clearing the emission regulations in each country/region to introduce these vehicles globally.

[Major countries' emissions regulations cleared by Mazda vehicles]

- Japan: WLTC Mode, a new emission regulation mode that has been in place since 2018.
- U.S.: Tier3/LEV2,3 regulations
- Europe: Euro 6 regulations
- China: China 5 regulations (equivalent to Euro 5)

*1 1,500 to 2,000 cc class, as of March 2017, according to Mazda data
*2 Models adopting the lightweight wiring harness (as of June 2019): Roadster/MX-5, Mazda3, CX-30, Atenza/Mazda6, CX-5, CX-8, and CX-9

Development of Unique Single-Nanotechnology

Mazda pays attention to global movements toward tighter control of exhaust emissions and fuel economy, market expansion due to rapidly growing emerging countries, and depletion of scarce resources. The Company has developed its unique single-nanotechnology and soot (PM) oxidation catalyst, promoting reduction of the use of precious metals and cleaning of exhaust gases.

Single-Nanotechnology Dramatically Reduces Consumption of Precious Metals j

Based on the belief that it is important to help three-way catalysts for gasoline exercise excellent catalyst performance after reducing the use of scarce elements, such as rare metals (precious metals) and rare earths (ceria material), Mazda developed in 2009 the world's first*1 single-nanocatalyst*2 that achieves both cleaner exhaust characteristics and higher durability while reducing the use of precious metals for vehicle catalysts by around 70% compared with the conventional figure at Mazda. Furthermore, Mazda succeeded in an additional 30% to 40% reduction in the consumption of precious metals needed for a single-nanocatalyst, and has been progressively introducing the technology since 2011, when it was first introduced into the Demio (Mazda2 overseas).

At present, this technology is employed in Mazda's clean diesel engine Skyactiv-D.

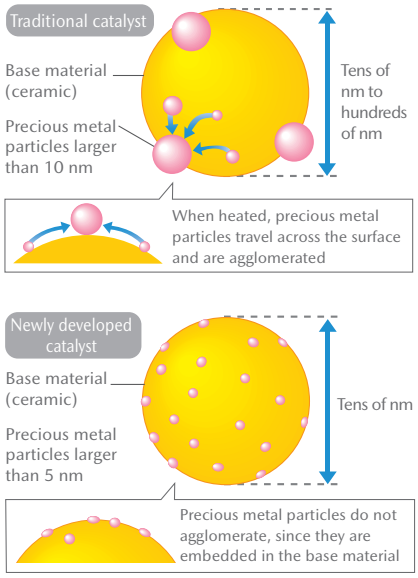
(For details, see the URL)

https://www.mazda.com/en/innovation/technology/env/other/singlenano_tech/

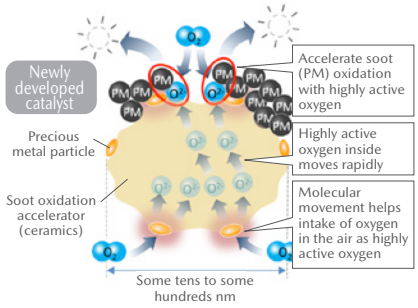
Technology to improve performance of PM oxidation catalyst k

Mazda has developed a unique PM oxidation technology for diesel engine catalysts, which enables rapid combustion and removal of soot (PM) and reduces CO_2 emissions. Compared with conventional catalysts, this technology effectively utilizes oxygen not only on the surfaces of catalyst particles but also of their inside, and enables supply of a larger amount of highly active oxygen for soot (PM), thereby achieving dramatic improvement in functions. The introduction of this technology has reduced the use of precious metals, or rare elements, to around one-tenth, along with the durability sufficient to maintain the catalytic function throughout the entire vehicle life cycle. The introduction began in 2009 into diesel engine models, and in the CX-30 in FY March 2020.

j Model of precious metal dispersion by new catalyst technology



k Mechanism of soot (PM) oxidation catalyst



Proper Management of Chemical Substances and Heavy Metals

Mazda publishes Management Standards for Environmentally Hazardous Materials, specifying substances and heavy metals whose use in parts and materials it purchases is subject to restrictions (prohibited substances and substances for which reporting is required), to properly control the use of such hazardous materials.

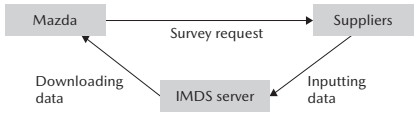
Collection and Management of Automotive Parts Materials l

Mazda is working across its entire supply chain to reduce the use of environmentally hazardous materials such as lead, mercury, hexavalent chromium and cadmium. Using the standardized IMDS*3, international system, the Company gathers information on the materials from suppliers (Met all of the voluntary targets of the Japan Automobile Manufacturers Association, Inc. (JAMA) (reduction of the use of lead and mercury, and prohibition of the use of hexavalent chromium and cadmium) by February 2007, earlier than the scheduled deadlines).

Measures Related to Application of IMDS

- To ensure that suppliers enter IMDS data appropriately, the Company publishes and distributes guidelines each year.
- The data gathered through IMDS is used to calculate the Company's vehicle recycling rate and to comply with various regulatory regimes for chemical materials, such as REACH*4 in Europe.

l How IMDS Works



*1 Granted a Japanese patent in November 2003, and granted an international patent in August 2005.
*2 Catalyst featuring single-nanotechnology to control finer materials structures than nanotechnology
*3 International Material Data System
*4 Registration, Evaluation, Authorization and Restriction of Chemicals

VOC Reductions in Vehicle Cabins

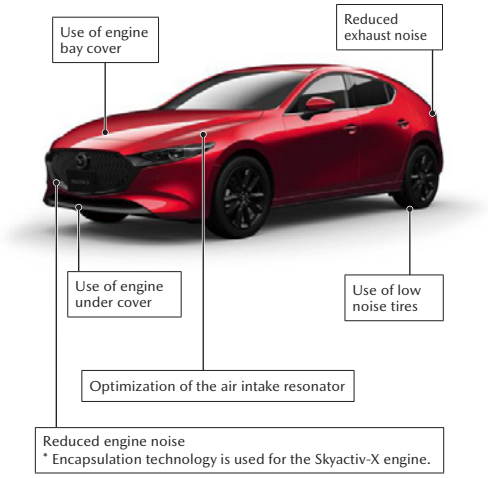
To maintain a comfortable cabin environment, Mazda is committed to reducing VOCs*1 such as formaldehyde, toluene and xylene, which have been implicated as possible causes of sick building syndrome.

- In new models, starting with the Demio (Mazda2 overseas) launched in 2007, Mazda reduced VOCs in the main materials used in the cabin, such as plastics, paints, and adhesives, thereby conforming with the indoor aerial concentration guidelines established by Japan's Ministry of Health, Labour and Welfare. (The CX-30, introduced in 2019, followed the above guidelines.)

Reduction of Vehicle Noise m

Mazda has established its own noise standards which are even stricter than the most recent legal requirements. In compliance with the above in-house standards, the Company has been working to reduce the road traffic noise of all the passenger vehicles and commercial vehicles it produces. The Company has also been actively addressing the development of technologies to reduce the three major vehicle noises: engine noise, air intake/exhaust system noise, and tire noise.

m Example of Anti-Noise Measures (Mazda3)



Promoting Resource-Recycling Initiatives

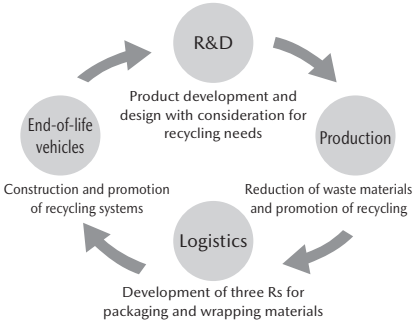
Product Development and Design with Consideration for Recycling Needs n o

Mazda builds resource-saving initiatives into every phase of the lifecycle of its vehicles, based on the three Rs: reduce, reuse, and recycle. Many limited resources are used to manufacture vehicles, such as steel, aluminum, plastics and rare metals. Mazda established the Recyclable Design Guidelines in 1992, and is incorporating three Rs design into all vehicles currently under development.

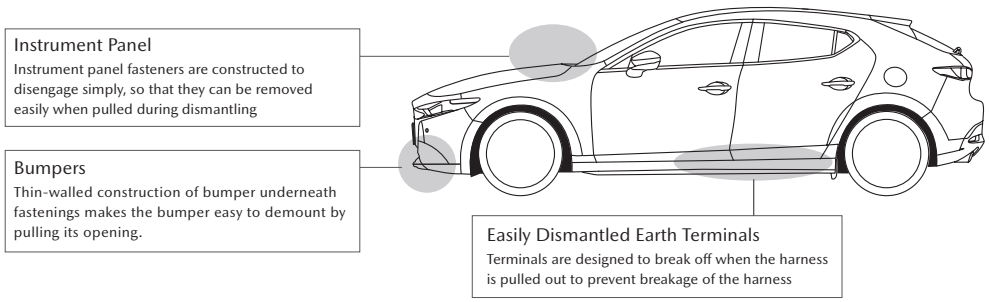
Mazda is steadily increasing the recyclability of its new vehicles, drawing on the following initiatives.

1. Research into vehicle design and dismantling technologies that simplify dismantling and separation, to make recyclable parts and materials easier to remove
2. Use of easily recyclable plastics, which constitute the majority of ASR*2 by weight

n Resource-saving based on 3Rs



o



*1 Volatile Organic Compounds
*2 Automobile Shredder Residue
It refers to the residue remaining after the crushing/shredding of what is left of the vehicle body following the removal of batteries, tires, fluids, and other parts requiring appropriate processing; the removal of engines, bumpers, and other valuable parts; and the separation and recovery of metals.

Expanded Adoption of Biomaterials p q

Mazda has been proactively developing plant-derived biomaterials which have the potential to help reduce environmental impact by curbing the use of fossil fuels and CO_2 emissions. In 2006, the Company became the first in the automotive sector to develop high heat-resistant, high-strength bioplastic for vehicle interior parts. In 2007, Mazda succeeded in the development of the world's first biofabric made with completely plant-derived fibers for vehicle seat covers. In 2014, bio-based engineering plastic*1, suitable also for use in vehicle exterior parts, was developed by the Company, which is currently expanding the adoption of this material.

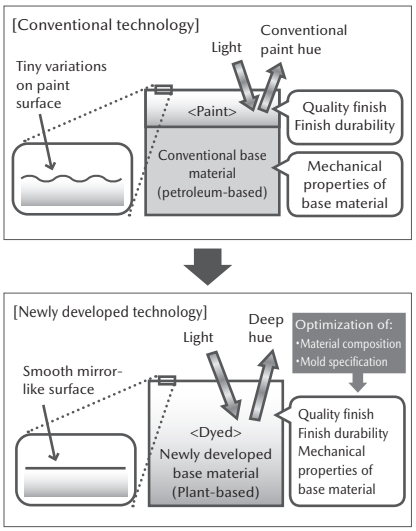
Adoption of Bio-based Engineering Plastic

2014: Mazda developed bio-based engineering plastic featuring a high-quality finish without painting. By developing paint-less technology for interior and exterior parts taking advantage of the characteristics of this material, the Company not only secured the excellent environmental performance of the material but also achieved a high-quality finish that could not be achieved with conventional paint, and contributed to environmental protection and production cost reduction by eliminating the painting process.

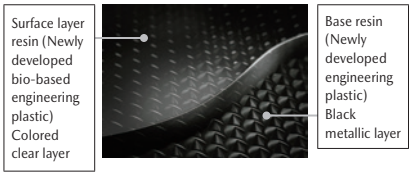
2017: Mazda developed materials suitable for making large, intricately shaped exterior parts, such as front grilles, and optimized the die specifications in order to substantially enhance the formability of these parts. In 2020, the Company was granted the Award for Science and Technology (Development Category) of the 2020 Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for the development of the above-mentioned bio-based engineering plastic.

2018: Mazda developed a new technology for two-layer molding of pattern designed bio-based engineering plastic, which enables the molding of a transparent surface layer and a base layer with a pattern-engraved surface, both of which are made of environmentally friendly bio-based engineering plastic. The new technology reduces environmental impact while making it possible to provide elaborated, shaded patterns of deep color, which was previously impossible with conventional technology.

p 2014: Development of paint-less technology for interior and exterior parts taking advantage of this material



q 2018: New technology for two-layer molding of pattern designed bio-based engineering plastic



*1 Bio-based engineering plastic was developed by Mazda Motor Corporation in collaboration with Mitsubishi Chemical Corporation.