

Interview with an Executive Officer | Research and Development Strategy and Sustainability



Ichiro Hirose
Director and Senior Managing Executive Officer (oversight of R&D, Cost Innovation and Innovation)

Research and Development Strategy and Sustainability

Amid the growing calls for the whole society to address climate change, the movement toward decarbonization and electrification is accelerating in the automotive industry. During the transition period from internal combustion engine vehicles (ICEVs), which have been the mainstream in the market, to hybrid vehicles (HEVs, PHEVs) and then to electric vehicles (EVs), it is increasingly important to conduct research and development in a way that can respond to uncertainties while keeping a long-term perspective. Here is an interview with Ichiro Hirose, Director and Senior Managing Executive Officer about the research and development strategies that have been pursued by Mazda as well as initiatives toward the future.

Mazda's Basic Approach to Research and Development

— Please tell us Mazda's basic approach to research and development.

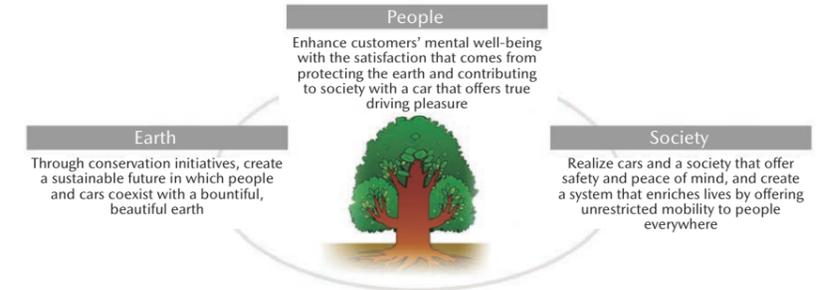
At the bedrock of our research and development strategy is "Sustainable Zoom-Zoom," Mazda's long-term vision for technology development.

Mazda announced its long-term vision for technology development "Sustainable Zoom-Zoom" in 2007. Later, in light of the significant changes in the global automobile industry, this vision was updated from a longer-term perspective, and in 2017 "Sustainable Zoom-Zoom 2030," a new long-term vision for technology development that looks ahead to the year 2030, was announced. Specifically, it declares that: "At Mazda, we see it as our mission to bring about a beautiful earth and to enrich people's lives as well as society. We will continue to seek ways to inspire people through the value found in cars." Upholding this as our guiding principle, we are promoting research and development with a consistent approach.

Regarding the earth, in order to substantively reduce CO₂

Sustainable Zoom-Zoom 2030

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emissions to address climate change, it is necessary to work on CO₂ reduction from a well-to-wheel perspective. Mazda currently operates in over 130 countries and regions around the world. Power supply conditions and environmental regulations that need to be observed vary by country and region. While some regions depend mainly on fossil fuels for power generation, other regions are rapidly shifting to renewable energy sources. Under these circumstances, we consider it necessary to provide multiple solutions, namely, offering various power unit choices including electrification, tailored to each country's environmental regulations and power generation mix. Mazda is unwaveringly pursuing a Multipule-Solution approach.

In the area of people, Mazda aims to provide people with experiences that Uplift and Energize People, Bringing More Enjoyment to Everyday Life through vehicles that offer exciting mobility experiences and Joy of Driving. In addition to further pursuing a *Jinba-ittai*—or sense that the car responds almost as though it were an extension of the driver's body—driving feel, which brings out potential of humans and uplifts the mind and body, we are working to further mature our Kodo Design language, which is grounded in a philosophy of bringing cars to life to enrich people's emotional lives.

In the area of society, in addition to realizing an accident-free society that offers safety and peace of mind, Mazda aims to provide people with mental satisfaction and revitalize communities. To this end, we are developing technologies that support drivers in driving safely and with peace of mind and help to prevent or reduce the damage

resulting from an accident if it were to occur due to a driver's mistake. Through development of these technologies, we want to offer safety and peace of mind not only to drivers but also to their family and people in the vicinity of cars.

To achieve this long-term vision, we have employed a product development strategy called Building Block concept.

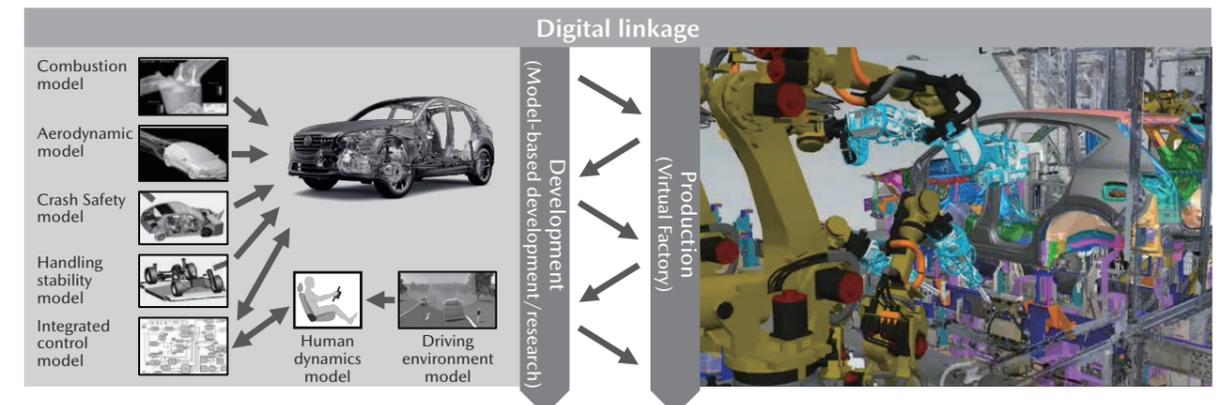
Under the Building Block concept, we have promoted *Monotsukuri* Innovation in stages to achieve a breakthrough in two contradicting goals of differentiation to enhance product appeal and of standardization for improved production efficiency. By pursuing the two pillars of *Monotsukuri*, which are Common Architecture concept and Flexible Production, it has become possible to develop and produce a variety of models with the same characteristics through bundled planning and development, realizing high-mix low-volume production that achieves both production efficiency and differentiation that leads to competitive advantage. Mazda has continued to build up assets created through *Monotsukuri* Innovation as building blocks, with each block serving as a foundation block upon which the next is built. By repeating this process, we have solidified our assets. I believe that continuing this process from a long-term perspective is indeed one of Mazda's strengths.

The Building Block concept involves two fields: process innovation and technological innovation. We have been promoting each innovation initiative in several phases.

From now, I will explain these two innovation initiatives in detail.

Model-Based Development and Research, and Virtual Factory (example)

Significantly increase investment efficiency for development and production by expanding the scope of application of model-based development through the use of AI and digital technologies



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Accumulation of Digital Technologies Which Enables Building Block Concept into Reality

— Please tell us Mazda’s strengths in process innovation.

The beginning of process innovation is Mazda Digital Innovation (MDI), which started in the 1990s. Based on the digital mockup containing all 3D data necessary for product design on a computer, Mazda established a digital factory, which digitally connects its extensive supply chain and value chain from upstream to downstream and performs virtual design and testing on a computer during the prototype fabrication and manufacturing processes. In the 2000s, continual investments were made to expand the computer capacity, leading to the realization of “prototype-less design,” which enables the designing of subsequent processes without using physical prototypes, and “virtual testing,” which enables the execution of various tests in virtual environments. We have thus completed one block, or asset.

And now, based on that asset, we are building up a new block, which will realize Mazda’s unique digital twin that synchronizes development and production. Achievements of these efforts in the field of research and development include Mazda’s unique Model-Based Development and Research (MBD and MBR), which have enabled us to develop the intended products in shorter times and at lower expenditure. In the conventional development method, we built the quality to the product based on verification results obtained from the process of making design drawings, manufacturing prototypes and performing physical tests. In other words, it involved the use of physical objects. Therefore, speed and efficiency were very limited. Also, with the increasing sophistication of technologies, it was difficult to obtain an optimal solution. The introduction of MBD and MBR has enabled us to, by accumulating and using “models,” conduct development process from design drawing to testing/verification without depending on physical objects, while also making it possible to obtain an answer on a computer even in the case of combination of sophisticated technologies.

Furthermore, we are working to expand the scope of application of MBD and MBR. Starting with the combustion model of the engine, we have expanded the application of MBD and MBR to include major performance factors of a vehicle, such as aerodynamics, crash safety, handling stability, integrated control, ride comfort, and quietness. And as a virtual factory, MBD and MBR have also been applied in the

production technology field. We have created “models” of the vehicle, drivers/passengers and driving environments by incorporating the results of research on human beings that has been undertaken through industry-academia-government collaboration.

This series of efforts to strengthen digital technologies has also contributed to enhanced risk response. For example, let me cite the case of mass production preparation of the CX-50 at the U.S. plant. Amid restrictions on free movement due to the novel coronavirus (COVID-19) pandemic, the U.S. plant virtually designed and established a production line, achieving the reduction of man-hours and costs for new model introduction and the shortening of preparation period. I think this was possible because Mazda had promoted MBD and MBR far ahead of the rest of the industry.

Mazda will continue striving to further strengthen its strengths by deepening collaboration with business partners including suppliers and other companies in the industry through MBD and MBR and widening a circle of co-creation.

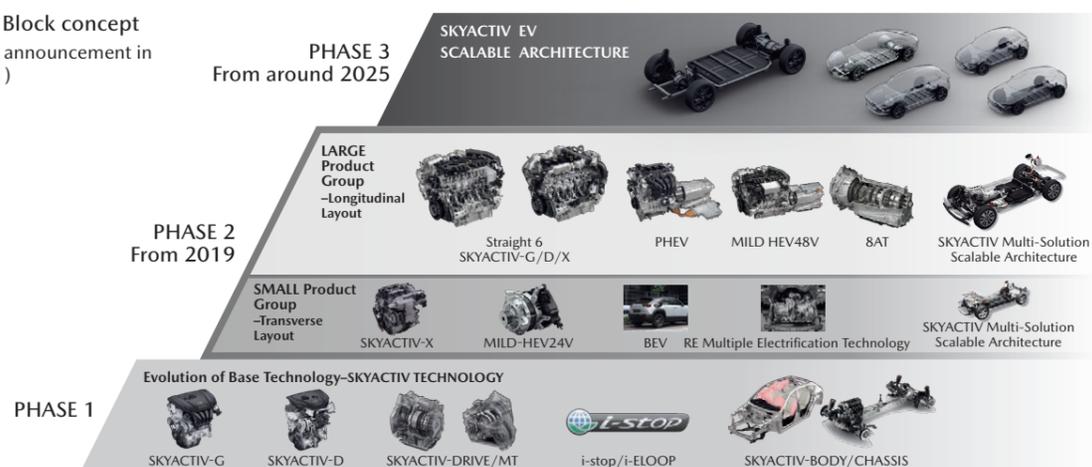
Accumulating Technological Assets in Line with Building Block Concept to Better Respond to the Electrification Era

— Next, please tell us about technological innovation.

As for technological innovation, we have finished Phases 1 and 2 and have just started Phase 3. In Phase 1, from 2007, in addition to upgrading technologies related to internal combustion engines centered on Skyactiv Technology, we built a base block on which to build up electrification technologies. In Phase 2, we continued to enhance our internal combustion engines and expand electrification technologies. Based on the Skyactiv Multi-Solution Scalable Architecture, we offer multiple choices of powertrains and architectures that combine various electric device technologies to meet various customers’ needs, and each country’s environmental regulations and power supply conditions. At present, technologies developed in Phase 2 are incorporated in our Large product. These technologies have been transformed into assets. In Phase 3, seeing the period up to FY March 2026, the final year of the current Medium-Term Management Plan, as an important period to accumulate electrification technologies in preparation for the full-scale electrification era, we plan to introduce our unique EV platform “Skyactiv EV Scalable Architecture” for EVs of various sizes and body types. While shifting our focus to EVs, we will

Building Block concept

(As of the announcement in June 2021)



strive to achieve our electrification goals. We expect that 100% of our products will have some level of electrification (including hybrid electric vehicles (HEVs) and plug-in hybrid vehicles (PHEVs)), and our EV ratio will be 25-40%* by 2030.

In addition to the environmental field mentioned above, we have also been building up blocks in the safety field since 2007 (see pp.55-56). In line with “Mazda Proactive Safety,” the Company’s safety philosophy, we have developed safety technologies based on research on human beings, with the aim of realizing an accident-free society that offer safety and peace of mind. As the first block, or the base block, in order to provide outstanding safety performance, we improved visibility and handling, and made improvements to vehicle body structures and layout to ensure ideal driving position by revamping vehicle body skeletons. These improvements have been installed into a wide-ranging lineup of models. As the second block, we added i-Activsense advanced safety technologies, including active safety technologies that support safer driving by sensing the vehicle’s surrounding area and alerting the driver when a potential hazard, like another vehicle or pedestrian, is detected. In the current third block, we are promoting the installation of technologies that help to avert collisions and other dangers by automatically decelerating and stopping the vehicle if it is deemed difficult for the driver to continue normal operation. Mazda’s basic approach is to provide safety and peace of mind to a greater number of customers by incorporating safety technologies that are currently available into its models instead of waiting until autonomous driving becomes pervasive and is put into practical use as social infrastructure.

While promoting these research and development strategies, we commence the launch of several new models in the Large product, which will become the pillar of our full-scale growth phase. As a first step, the CX-60 was released. In the European market, where electrification is already in full-swing, we introduced a PHEV model, Mazda’s first plug-in hybrid. In Japan, we will introduce a model equipped with e-Skyactiv D, which combines a straight-six diesel engine with a mild hybrid system. With regard to safety technologies, these models are equipped with the Driver Emergency Assist (DEA), which monitors the driver’s condition and automatically decelerates and stops the vehicle if it detects an inactive driver, and a series of functions to avoid collisions and other dangers and place an emergency call through connected care technology. Mazda plans to commence production of the CX-90 for the North American market in the fiscal year ending March 2023, and to introduce

the CX-70 for the North American market and the CX-80 in Europe and Japan.

Multiple-Solution That Seeks to Offer Multiple Practical Options to Help Realize a Carbon Neutral Society

— Please tell us Mazda’s policy for product and technology development toward 2030.

Mazda declared in 2021 that it would endeavor to achieve carbon neutrality (hereinafter, “CN”) throughout its supply chain by 2050. Such a declaration was possible only because of the blocks, or technological assets that the Company has built up one by one since 2007. We intend to achieve our CN goal by further building up new blocks.

The growing social movement toward CN is driving a shift toward EVs. However, to achieve this, there are still many challenges to overcome, and we don’t think the shift to EVs will happen overnight. Viewing the period up to around 2030 as a transitional period, we plan to promote the shift to EVs in stages, in accordance with the regulations and demand of each region. I think this is a realistic plan. We believe that during this transitional period, it is necessary to make strategic preparations toward full-scale popularization of EVs, while at the same time pursuing continuous evolution of internal combustion engines which will remain in use for decades to come.

Regarding the evolution of internal combustion engines, we believe the most important thing is to reduce the energy consumption. Biofuels and CN liquid fuels are expected to be realistic options by around 2030. Therefore, in preparation for the use of these CN fuels, it is still important to improve the efficiency of internal combustion engines to the highest level possible in terms of reduction of energy consumption.

Regarding EVs, Mazda plans to release several EV models during the period from around 2025 to 2030 by building up new blocks on top of the blocks of electrification technologies accumulated through the development of the MX-30 EV and the CX-60 PHEV.

By further evolving our technological assets accumulated through Building Block concept and by taking our unique Multiple-Solution approach which seeks to offer a variety of combinations of internal combustion engines and electrification technologies tailored flexibly to customer needs and each country’s conditions, we will promote our efforts to address climate change and social contribution activities.

Mazda has consistently pursued its own unique philosophy since the announcement of “Sustainable Zoom-Zoom” in 2007. Vehicles are responsible for people’s lives. The Company will continue to pursue car manufacturing that will contribute to society by enriching people’s lives and supporting safe and secure mobility. We will also strive to create cars that inspire people and bring out their potential and abilities by pursuing continuous evolution of Joy of Driving. We are committed to contributing to realizing a sustainable society by continuing to refine our technological strengths while working in collaboration not only with business partners, including local suppliers in Hiroshima and Yamaguchi prefectures, and other companies in the same industry, but also with companies in other industries.

[Crossover SUVs already introduced or to be introduced from 2022 onward]

Product group	Models	Major markets to receive the models
Large Product group	MAZDA CX-60 (Two rows)	Europe, Japan, etc.
	MAZDA CX-70 (Wide body, two rows)	North America, etc.
	MAZDA CX-80 (Three rows)	Europe, Japan, etc.
Small Product group	MAZDA CX-90 (Wide body, three rows)	North America, etc.
	MAZDA CX-50	North America

*Based on the information announced in November 2022 in the “Medium-Term Management Plan Update and Management Policy up to 2030”