Creating New Value by Anticipating the Future: MHI FUTURE STREAM

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MHI FUTURE STREAM is an activity for setting Mitsubishi Heavy Industries, Ltd. Group's business direction according to megatrends in surrounding political, economic, social, and technological situations, and accelerating our business transformation. This report details the challenges that we have taken on based on megatrends and describes the social significance of our challenges.

1. Review of megatrends in MHI FUTURE STREAM

In recent years, geopolitical risks and associated supply chain reorganization have become apparent, with behavioral changes caused by the COVID-19 pandemic and the prolonged conflict in Ukraine, in addition to the complication of social issues, diversification of value and progress in digital technology and biotechnology. Furthermore, various changes have been occurring in the fields of politics, economics, society, and technology, such as internationally accelerating actions to address climate change issues.

For Mitsubishi Heavy Industries, Ltd. (hereinafter referred to as MHI) Group to continue to contribute and provide value to all our stakeholders in such a world represented by the term VUCA*, it is important for us (1) to capture major trends that remain unaffected by daily changes, and (2) to envision a future society based on major trends and determine our business direction. Therefore, in 2018, we launched MHI FUTURE STREAM, which is an activity for promoting constant business transformation.

*VUCA: Volatility, Uncertainty, Complexity, Ambiguity

MHI FUTURE STREAM involves the following three actions: "MEGA SCAN," "SHIFT THE PATH" and "TECHNOLOGY SCOUTING" (**Figure 1**).

In "MEGA SCAN," the scenarios of likely changes are formulated considering wide-ranging possibilities in markets and technologies from a broad, comprehensive perspective of megatrends in the political, economic, social and technological situations surrounding MHI Group and then potential business opportunities are conceived. In this activity, numerous dialogues are held with experts and innovators both inside and outside our group, and insight into the future and visions are created from multiple perspectives on markets and technologies. "MEGA SCAN" thus enables us to gain insight into changes not by considering them as a set of individual phenomena but by capturing the overview of changes as a flow.

"SHIFT THE PATH" generates innovation hypotheses of markets and technologies based on the insights and perspectives from "MEGA SCAN," and explores the business opportunities found therein. "SHIFT THE PATH" deals with subjects that are difficult to develop and nurture in current business divisions, such as new businesses unrelated to existing businesses or business opportunities crossing multiple domains. Led by the agile business development team together with external partners such as startups, prototyping and trials to verify innovation hypotheses are conducted.

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"TECHNOLOGY SCOUTING" has two key concepts. One is to find disruptive technology seeds that may have a significant impact on the medium- to long-term insight/vision obtained in "MEGA SCAN." The other is to co-create technologies needed to realize the innovation hypotheses generated through "SHIFT THE PATH" together with external partners.

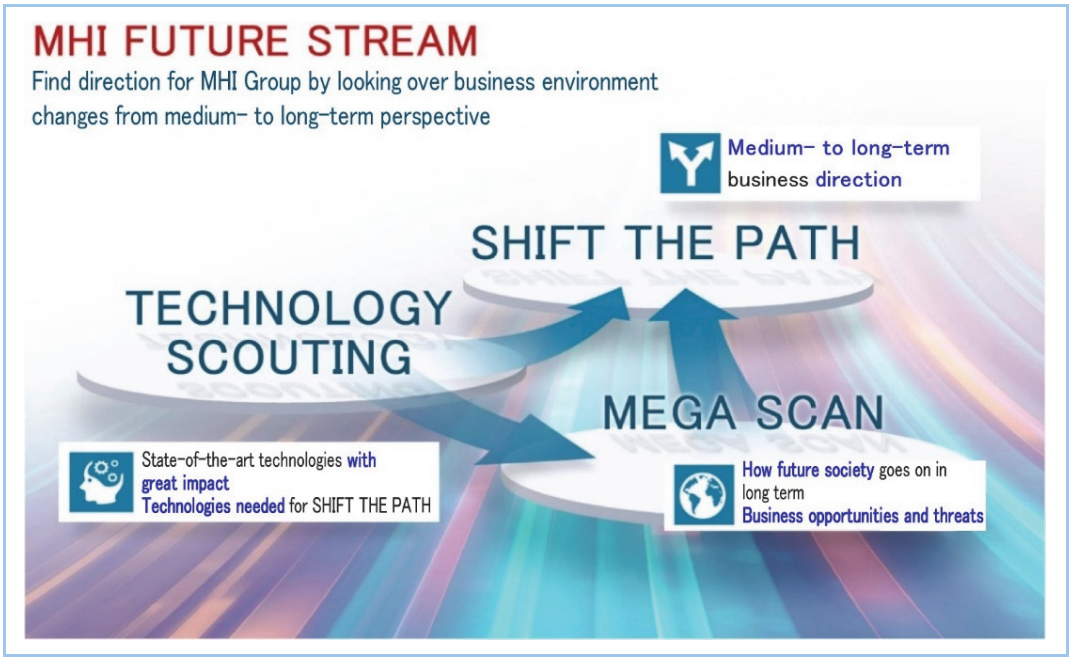

Figure 1 Three actions of MHI FUTURE STREAM

This report introduces specific examples of the actions of MHI FUTURE STREAM.

2. MHI Group's challenge in line with megatrends and undercurrents

MHI FUTURE STREAM, which we have been working on since 2018, is producing new challenges for MHI Group. The previous reports[1],[2] described the roles that we should play in the midst of the changing medium- to long-term trends, and our Group's challenges in line with the trends have been making steady progress and are being materialized (**Figure 2**).

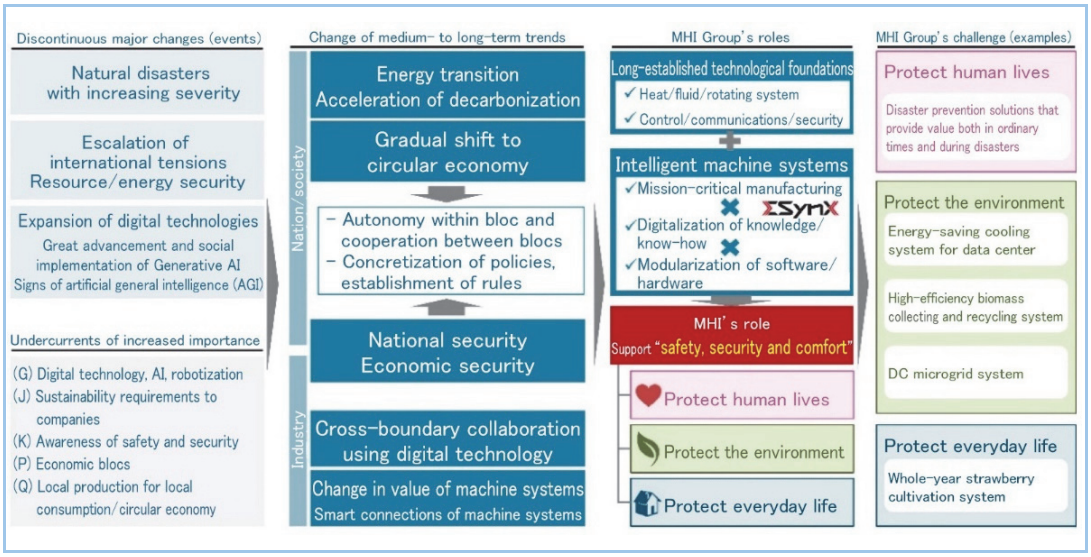

Figure 2 MHI Group's challenge in light of megatrends (Examples)[1],[2]

2.1 Disaster prevention solutions that provide value both in ordinary times and during disasters

(a) Necessity of provision of value both in ordinary times and during disasters

Weather disasters caused by climate change have been increasingly severe in Japan and overseas in recent years, and social infrastructure will need to adapt to climate change and

improvement of resilience (strength and power of recovery). MHI Group aims to contribute to building a safe and secure society by providing customers with infrastructure products and services for improvement of resilience. For various types of disasters such as floods, tsunamis, earthquakes, typhoons, fires and leakage/explosions, we have developed numerical simulation technologies[3]~[5] to predict infrastructure damage and formulate precautionary measures to minimize the damage, and have applied them to actual equipment and plants.

On the other hand, the common elements for resilience improvement are energy, data and supply chain, but it is difficult to promote investments intended only to improve resilience because (1) no need is felt for disaster prevention equipment in ordinary times and (2) there is no established method for evaluating the value of investment in prevention of natural disasters which are uncertain about the occurrence timing and extent. Therefore, we are promoting efforts to provide value both in ordinary times and during disasters to customers by combining MHI Group products.

(b) Systems that provide value both in ordinary times and during disasters

Figure 3 shows an example of the system that provides value both in ordinary times and during disasters by utilizing MHI Group products. It configures a machine system that realizes provision of new value, such as carbon neutrality, data processing and automation, to customer's major operations in ordinary times. We functionally classify these products from the point of view of three factors for resilience, i.e., energy, data and supply chain, newly define resilience improvement value during disasters and are proposing them to customers.

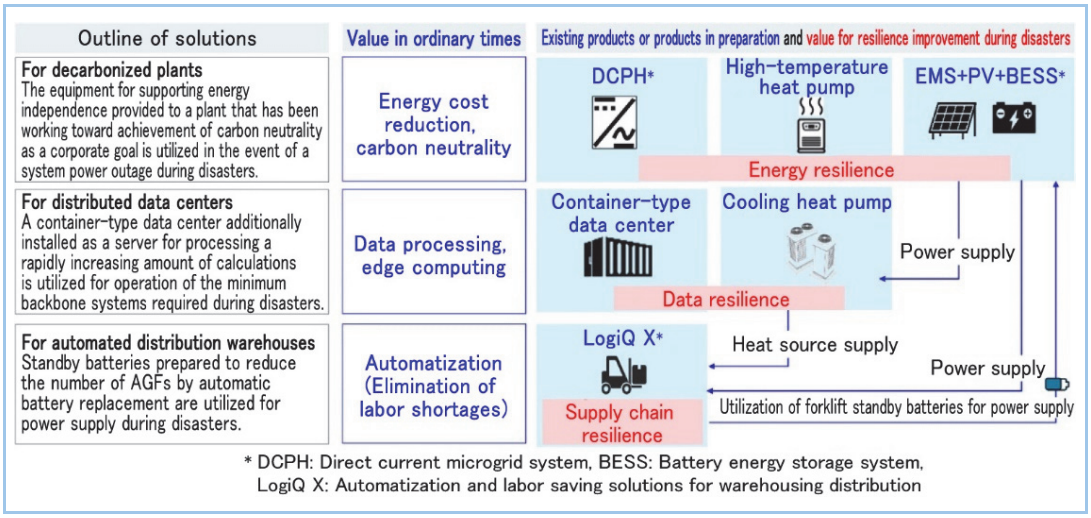

Figure 3 Example of system that provides value both in ordinary times and during disasters by utilizing MHI Group products

2.2 Energy-saving cooling systems for data centers[6]

(a) Issues and solutions for improvement of energy efficiency of data centers

In recent years, with the progress of digitalization, the demand for data centers has been rapidly growing. Especially, the data amount in 2025 is expected to increase by a factor of about 150 compared to that in 2010[7], and the power consumption in data centers is also expected to increase. The power consumption of cooling facilities accounts for about 30% and this is a big challenge toward the realization of carbon neutrality[6]. Furthermore, with the acceleration of the introduction of Generative AI in the future, the use of high-heat-generating chips (CPU and GPU) is expected to increase and conventional air-cooling systems will be unable to satisfy the cooling demand. To cope with these circumstances, MHI Group participated in the development of a new container-type data center system using a liquid cooling method and achieved a reduction of power consumption and a significant improvement of PUE (Power Usage Effectiveness) (**Figure 4**).

(b) Features of liquid cooling system and improvement of energy efficiency

Among liquid cooling methods, a liquid immersion cooling technology was adopted in the container-type data center system that MHI Group developed, which has realized energy saving with high efficiency in combination with an outside air cooling device. In this system, the server

is immersed in liquid (oil) to efficiently remove heat using liquid with a higher heat transfer coefficient than that of gas. This allowed for cooling even in an environment where the outside air temperature exceeds 40°C, resulting in the reduction of PUE to 1.07 or less[6]. Assuming there will be Multi-access Edge Computing (MEC), we will promote further miniaturization and lower PUE, aiming at optimization of large-scale systems including hyperscale data centers, thereby developing technologies that meet the needs of customers.

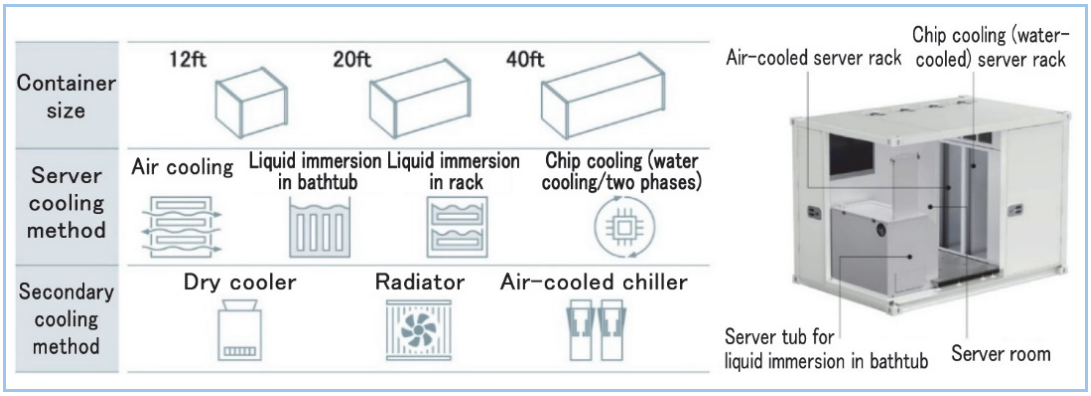

Figure 4 Container-type data center system[8]

2.3 High efficiency biomass collecting and recycling system[9]

(a) Maximum utilization of waste biomass as green energy source

Toward the establishment of a material-cycle society, the waste disposal industry sector has seen a growing need for separately collecting, to the extent possible, biomass resources such as food waste and paper from waste and recycling them. However, it is not easy to separately collect biomass resources from waste containing plastics, metals, etc., and it has been a challenge in the promotion of recycling.

MHI Group has developed the “high efficiency biomass collecting and recycling system (AdBio®)” for facilitating the separate collection of biomass resources from waste that had to be incinerated due to the difficulty in separate collection and converting them into recyclable materials with high efficiency.

This system can be used not only in the waste disposal sector but also in the agricultural sector. It allows agriculture promotion through generation of green energy from unused biomass such as agricultural residue and effective utilization of recovered heat, green CO_2, fertilizers, etc. The system can also contribute to the establishment of a sustainable agricultural production and food system for reducing environmental load.

(b) Features of AdBio and energy recovery effect through combination with biogasification

AdBio consists of a reactor for reacting materials to be treated with saturated vapor at a constant temperature and pressure, and a separator for separating reactants into biomass resources, such as kitchen waste and paper, and unsuitable materials for recycling, such as plastics and metals. Only biomass resources are finely granulated at the reactor. Therefore, (1) biomass resources can be easily collected at the separator in the subsequent stage, and (2) the decomposition rate is increased by heat treatment and high efficiency recycling becomes possible.

One example of treatment when AdBio is applied to municipal solid waste (general waste) in which various materials are mixed is shown (**Figure 5**). It is estimated that for municipal solid waste containing about 60% biomass resources (dry weight base), when AdBio and wet methane fermentation are applied in combination, biogas generation will be 1.2 to 1.3 times larger than that of the conventional method, which consists of crushing, separation and dry methane fermentation.

Through provision of AdBio, we will contribute to the efficient recovery of carbon neutral energy and the establishment of a material-cycle society.

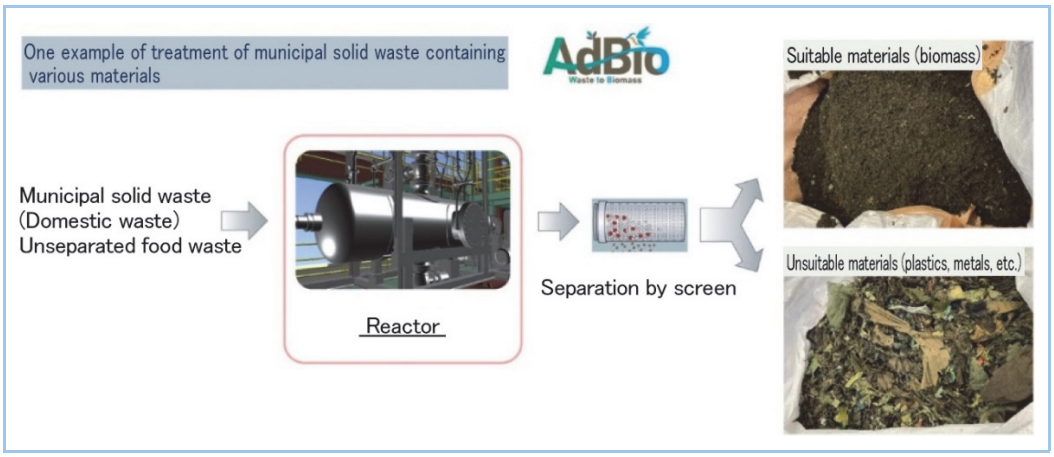

Figure 5 High efficiency biomass collecting and recycling system

2.4 DC microgrid system

(a) Realizing high economic efficiency by fully utilizing green electricity without waste

Since the effects of global warming and climate change are becoming more and more serious, the importance of efforts to contribute to decarbonization is increasing. For example, as represented by the shift to EV, the energy sources of various power demand products have shifted to electricity while renewable energies such as solar power and wind power are used as the power source.

Many electricity consumers, however, face an issue on how they should simultaneously achieve decarbonization and economic efficiency in their new efforts such as introduction of solar power generation and electrification of power demand products.

For customers who face such an issue, MHI Group has developed and proposed a DC microgrid system that contributes to the decarbonization and economic efficiency improvement of customers.

(b) DC microgrid system that contributes to improvement of economic efficiency and BCP* of electricity consumers

The DC microgrid system that MHI Group has proposed (**Figure 6**) is a solution for utilizing green electricity without waste by connecting various electric demand devices to photovoltaic panels and stationary storage batteries with a DC hub. In addition, the operation management of connected equipment is conducted by the control system on the cloud, facilitating the customer's efforts toward decarbonization. Furthermore, with the functions of peak shifting by utilizing stationary storage batteries, autonomous operation in the event of power outage and responding to the electricity trading market, this system also contributes to the improvement of economic efficiency and support of BCP.

*BCP: Business Continuity Planning. Planning for minimizing damage and promoting continuance and restoration of business when a state of emergency such as a disaster occurs.

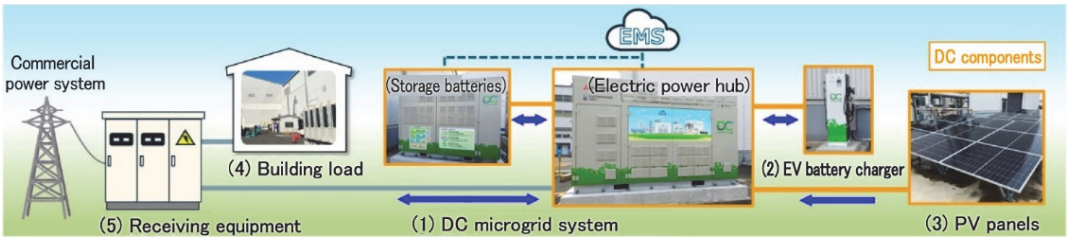

Figure 6 DC microgrid system

2.5 Whole-year strawberry cultivation system[10]

(a) Necessity of stable production of crops adapting to global warming and decarbonization

In recent years, climate change, especially, rising temperatures, has been significantly affecting the agricultural sector and suitable cultivation locations have been moving northward. Especially, high temperatures in summer in Japan have a serious impact on cultivation of crops,

especially strawberries. In addition, in the agricultural sector, there is a growing demand for decarbonization and the introduction of environmentally friendly production systems is required.

To respond to these changes, MHI Group aims to contribute to the agricultural field adapting to climate change by utilizing our technological foundations such as heat, fluid and control technologies and our product foundations such as air-conditioning equipment and agriculture-related facilities.

(b) Whole-year strawberry cultivation system

In light of the effects of higher temperatures on agricultural production, MHI Group has developed a system which allows whole-year cultivation of strawberries even in seasons when stable production is difficult. Specifically, working jointly with Ryono Engineering Co., Ltd., which is a group company, we provide a system for controlling the temperature environment and stably cultivating strawberries that is not affected by outdoor air temperatures.

The use of this system allows a stable harvest of high-quality strawberries even in summer and fall in Japan, which are not suited for cultivating strawberries, and can help agricultural producers. We confirmed that high-quality strawberries could be harvested in a test facility even on extremely hot days with the outside air temperature reaching 39°C. Based on the result, we started accepting orders on a full scale (**Figure 7**).

This system uses a technology for automatically controlling the temperature most suitable for the growth of strawberries based on data analysis. Through air conditioning and our unique cooling system, it provides an optimal environment for growth of strawberries while reducing energy costs. Furthermore, in combination with photovoltaic facilities, the system can realize reduction of CO_2 emissions and energy costs.

Thus, MHI Group will provide solutions to agricultural issues caused by global warming by using our air-conditioning and refrigeration products and control technology to contribute to solving problems caused by climate change in the agricultural sector.

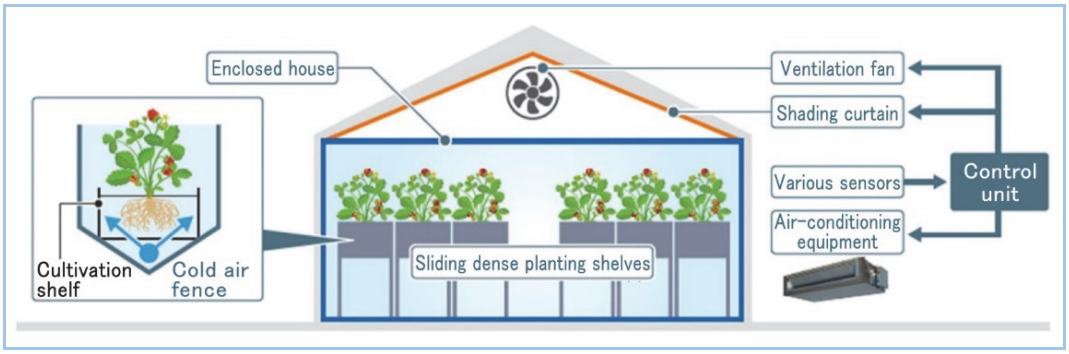

Figure 7 Basic constitution of whole-year strawberry cultivation system

3. Conclusion

This report described MHI Group's challenges that are being taken on six years after the start of MHI FUTURE STREAM.

For MHI Group to contribute to the sustainable growth of society while facing uncertainties in its surrounding business environment, the importance of MHI FUTURE STREAM will increase. MHI Group will identify megatrends that remain unchanged even in the VUCA business environment and issues faced by MHI Group and its customers and continue to take on the challenge to find solutions to them.

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