

Fuji Electric's Food Distribution Creating New Value: Current Status and Future Outlook

ISHIBASHI, Masanobu*

1. Introduction

The history of vending machines in Japan is said to have begun with a stamp and postcard vending machine that appeared in 1904. Nearly 60 years later, in 1962, a foreign beverage manufacturer entered the Japanese market. Fuji Electric started producing and selling milk vendors in 1965, and a cup-type coffee vending machine was installed at the Osaka Expo in 1970. Since then, vending machines have been developing in tandem with Japan's rapid economic growth as products that play a role in expanding sales for beverage manufacturers. Since open showcases were first sold in 1973, they have supported sales growth for retail stores as products that form a part of the sales floor.

With the global trend toward environmental protection aimed at achieving the Sustainable Development Goals (SDGs) and realizing carbon neutrality, as well as changes in the social environment such as the declining population and the COVID-19 pandemic, companies are being urged to protect the environment and contribute to society.

Fuji Electric is working to acquire technologies capable of addressing market changes in order to contribute to customer sales growth and environmental protection. This paper describes the current status and future outlook of Fuji Electric's food distribution business, which creates new value in the form of new technologies and products such as these.

2. Contribution to Global Environmental Protection

To achieve the government's declared goal of realizing carbon neutrality by 2050, Fuji Electric's customers are also working to expand their use of renewable energy and conserve resources by setting their own environmental targets. Among these targets, energy saving has become a top priority because it has the effect of curbing the rise in running costs associated with the recent rise in electricity prices.

2.1 Heat pump*¹ technology for beverage vending machines

Figure 1 shows the trend in the annual amount of power consumption per beverage vending ma-

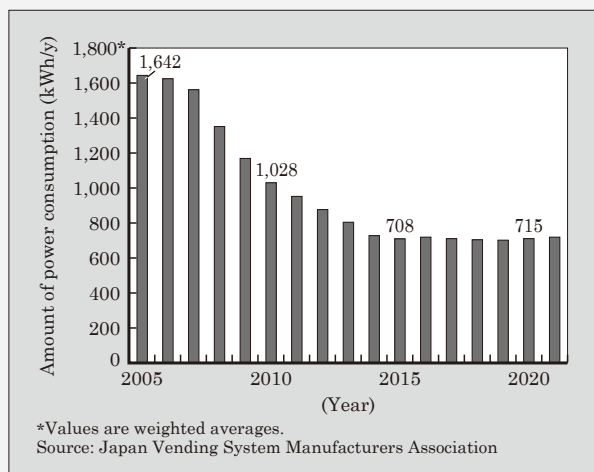


Fig.1 Trend in annual amount of power consumption per beverage vending machine

*1: Heat pump

A heat pump pumps heat from a low temperature area to a high temperature area. This makes the temperature of the low temperature area even lower and of the high

temperature area even higher. This principle is also used in refrigerators and air conditioners. A refrigerant transfers heat between indoor and outdoor units to cool or warm the air. Heat pumps, which can trans-

fer more heat than the workload of a compressor, are gaining attention as an effective means of saving energy.

* Food & Beverage Distribution Business Group, Fuji Electric Co., Ltd.

chine. The amount of power consumption, which tended to decline year by year, has become stagnant since 2015, prompting calls for further energy saving. Beverage vending machines use a heat pump to simultaneously heat and cool the interior. Fuji Electric has been striving to achieve energy saving in the operation of the heat pump.

Figure 2 shows the heat pump mechanism of beverage vending machines. In beverage vending machines installed in a variety of locations both indoors and outdoors, the heat pump load fluctuates depending on a variety of factors, including the outside air temperature, the number of items stored and their sales. In addition, when the seasons change, some of the chambers in the machine are switched from cooling to heating. We have developed a control technology capable of adjusting the heat pump operating method to maximize efficiency under these conditions and maximize energy savings throughout the year.

Heat pumps operate most efficiently under a balance between heating and cooling. When the load on the heating side grows due to external factors, the evaporation and condensation temperatures of the refrigerant in the heat exchanger of the heat pump are adjusted so that the performance against the load is equal on the heating and cooling

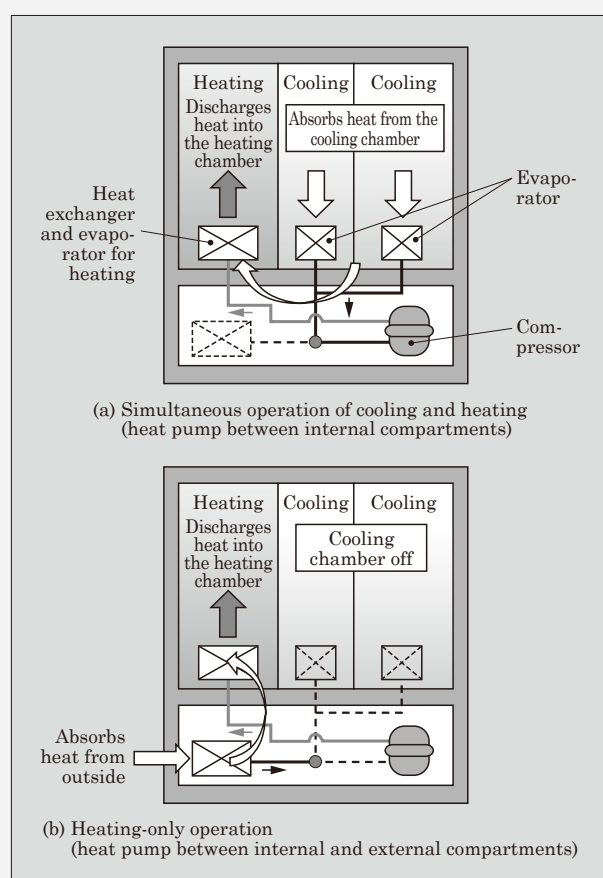


Fig.2 Heat pump mechanism of beverage vending machines

sides.

By applying this heat pump synchronization control as the highest priority in operation, we have eliminated the need for the heat pump between the interior and exterior, as shown in Fig. 2(b), thereby achieving energy saving (refer to “Technology for Applying Heat Pumps to Beverage Vending Machines” on page 119).

2.2 Showcase energy-saving technology

Among the equipment used in supermarkets and convenience stores, showcases that keep products cooled at suitable temperatures are easily affected by outside air because the product display area is open. For this reason, they consume more energy than refrigerators, which cool the interiors of enclosed chambers. Accordingly, energy saving of showcases is an important challenge.

Showcases are generally classified into two types based on the location of the cooling unit. Known as a built-in showcase, the first type is equipped with a cooling unit inside the showcase that cools the displayed items. The other type, called a separately installed showcase, has a cooling unit outside of the store, which is connected to multiple showcases in the store, as shown in Fig. 3.

For separately installed showcases, piping work is carried out on site, and the lengths and bends of the pipes vary from store to store, which often causes the amount of refrigerant contained in the pipes to vary, making them difficult to optimize. To address this, we have developed and are offering a tool that can be easily used on site to calculate the optimal amount of refrigerant to fill according to the piping capacity. It has been shown to optimize the amount of refrigerant filled at the time of installation, increasing energy savings for the entire store.

We have also developed a control system using an electronic expansion valve capable of optimizing operating conditions, which was difficult with conventional mechanical expansion valves (refer to “Energy-Saving Technology for Showcases” on page

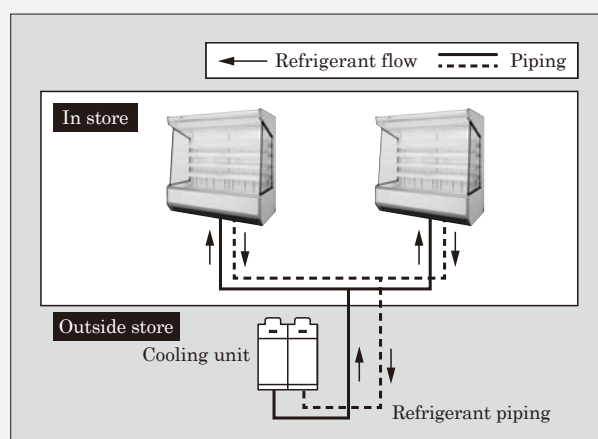


Fig.3 Separately installed showcase

140).

2.3 Energy saving system for stores

As mentioned in Section 2.2, showcases are susceptible to outside air, and the equipment units within a store affect each other. For this reason, it is important to operate the showcases in such a way that saves energy for the entire store, rather than simply improving the efficiency of individual units. In addition, it is necessary to ensure that visitors to the store feel comfortable. For example, while it is generally recognized that raising the temperature setting on the air conditioning during summer is an effective way to save energy, it may have a negative effect on the level of comfort experienced by visitors, which can affect sales. For this reason, it is not easy to save energy and ensure comfort at the same time. To address this, we identified the factors affecting energy saving in actual stores and analyzed their relationship with comfort. Using an index called the predicted mean vote (PMV) to quantify comfort, we studied not only the use of refrigeration equipment and air conditioning, but also the introduction of outdoor air, aiming to achieve both energy saving and comfort (refer to “Energy-Saving Measures for Stores” on page 144).

3. Addressing Changes in the Japanese Market

Under the trend of declining birthrates, an aging society, and a shrinking population, ensuring sales and saving manpower and labor are important challenges in the retail industry. On top of this, while the COVID-19 pandemic has upended the market environment and dealt a major blow to existing businesses, it has also created new needs, such as the need for non-face-to-face sales. In this period of change, there is a demand for the discovery of new opportunities.

3.1 New value-added services of vending machines

Fuji Electric has already been offering vending machine services for businesses that operate vending machines to help improve their operational efficiency. In response to the recent accelerating trend toward greater demand for contributions to the SDGs, operator companies are also stepping up efforts to improve their working environment and reduce food loss and waste. One by one since 2020, we have been offering new and expanded services that address these issues while increasing sales at the same time.

As a platform for providing these services, we have equipped our vending machines with a multi communication unit (MCU) (see Fig. 4). New services using the MCU include dynamic pricing, which enables automatic updates of the sales price display;



Fig.4 Multi communication unit

a smartphone remote controller, which enables operators to use a smartphone app to perform operations such as configuring the vending machine; and New QR Code* Payment, which enables the introduction of cashless payment at a low cost. These features reduce the need to perform tasks that were previously performed by workers, such as making rounds to vending machine locations to replenish items, collecting money, and changing price display when replacing items. In addition, these features make it easier to sell off products at a discount when they are approaching their best-before dates (refer to “Expansion of Vending Machine Operation Services” on page 114).

3.2 Networking in convenience stores

There is a need for convenience stores and other establishments to save energy while introducing new products and equipment to keep up with changes in the market. In addition, responding to the labor shortage caused by the declining birthrate and aging population has become a major issue, and there is a need to save energy as well as manpower and labor in operations. Fuji Electric provides a system to support store operations through the use of networked store equipment.

Figure 5 shows an example of the configuration of a system that uses a store controller. By monitoring and analyzing the operating status of showcase main units and the cooling unit through this system, not only can energy-saving control of the cooling unit be achieved, but predictive maintenance can also be performed through the detection of signs of equipment malfunction (refer to “Network Services for Stores” on page 137).

3.3 “Thickened beverage vending machine”

In Japan, where the population is aging, the number of care receivers is increasing, and at the

* QR code is a trademark or registered trademark of DENSO WAVE INCORPORATED

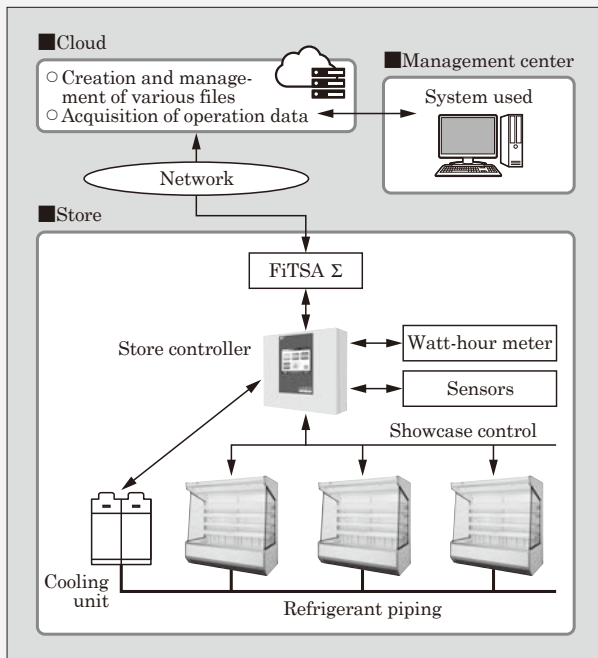


Fig.5 System configuration for store controller

same time, the shortage of labor required to provide nursing care services is becoming increasingly severe. Since people in need of nursing care are prone to aspiration when eating, for example, measures have been taken to thicken their beverages and make them easier to swallow. Because these thickened drinks need to be prepared according to the condition of the care receiver, preparing them required a lot of effort.

To address this, Fuji Electric has applied the technology it cultivated in the development of cup vending machines to develop an automatic tea dispenser with an in-cup mixing system, which prepares thickened drinks (see Fig. 6). It enables thickened drinks tailored to the condition of each user to be prepared with simple operations, and is also de-



Fig.6 "Thickened Beverage Vending Machine"

signed to operate with minimal maintenance, thus reducing the workload of caregivers who serve thickened drinks (refer to "Thickened Beverage Vending Machine' In-Cup Mixing Automatic Tea Server" on page 128).

3.4 Frozen food vending machine

Lifestyle changes due to the COVID-19 pandemic have led to rapid growth in the ready-made meal market. Among such products, frozen foods are attracting attention from the perspective of the SDGs as a means to address food loss and waste because of their long shelf life as well as improved quality due to developments in freezing technology.

In the restaurant industry, which has experienced a decline in sales during the COVID-19 pandemic due to stay-at-home policies, shortened business hours, and the general trend toward non-face-to-face communication, vending machines are seen as a promising new sales method to recover from the decline.

With this in mind, Fuji Electric has developed the "Frozen Station," a new frozen food vending machine (see Fig. 7). It is equipped with a spiral rack that can be used to sell a wide variety of products, and the space inside is effectively utilized to accommodate large items and increase the number of items that can be stored. We also used simulations to analyze the movement of conveyed items and develop a conveyance mechanism that ensures that items can be delivered without issue. In addition, we also provide operation support services to enable those who are unfamiliar with operation of vending machines to use them without trouble. This service is geared toward customers who have never operated vending machines before and is expected to expand the market for frozen food sold in vending machines (refer to "Frozen Station' Frozen Food Vending Machine" on page 123).



Fig.7 "Frozen Station" frozen food vending machine

4. Taking on Challenges for Further Growth

This section describes other solutions for the Japanese and international markets. We conduct research and development to create new value by addressing issues in society and improving convenience for customers.

4.1 General-purpose goods vending machines

In Southeast Asia (including Thailand, Malaysia, Singapore and Indonesia), more than 10,000 food vending machines have already been installed. In recent years, convenience store chains have entered the vending machine business, and demand for the sale of a variety of beverages and foods has been on the rise. The variety of the shapes of cans and plastic bottles sold in this region is incomparably greater than in Japan and cannot be handled using beverage vending machines for the domestic market. In Taiwan, the use of vending machines for dispensing pharmaceuticals at hospitals is being considered. This is because vending



Fig.8 “FGG160DCY”

machines are expected to be useful for preventing human error by pharmacists and for storing pharmaceuticals at constant temperatures.

Accordingly, Fuji Electric has developed a vending machine equipped with a product conveyance mechanism that can store many items of various shapes and dispense even soft items without damaging the shape of the contents (see Fig. 8) (refer to “FGG160DCY” General-Purpose Goods Vending Machine” on page 132).

4.2 Edge devices

As the demand increases for real-time performance to provide further benefits, the increasingly popular Internet of Things (IoT) systems are changing from traditional cloud-centric configurations to more sophisticated configurations that enable processing to be performed on edge devices.

Accordingly, in order to meet diverse needs, Fuji Electric has defined the requirements and pursued software to achieve a new IoT platform. We have thus developed the edge computing device that forms the fundamental technology for edge devices.

We have leveraged open-source software (OSS) to provide flexibility for meeting diverse needs and reduce the time required for application development. The hardware is configured with enhanced connectivity and is capable of both wired and wireless connection. The configuration of function modules has been innovated to facilitate future updates. Security software is provided as standard, ensuring secure use (refer to “Fundamental Development and Application of the Next Generation Edge Devices” on page 154).

4.3 Frost-free technology for heat exchangers

Heat exchangers are used not only in showcases and vending machines, but also in refrigerators and other equipment used to cool objects. The evaporative latent heat of the refrigerant circulating inside the heat exchanger is used to cool the interior of

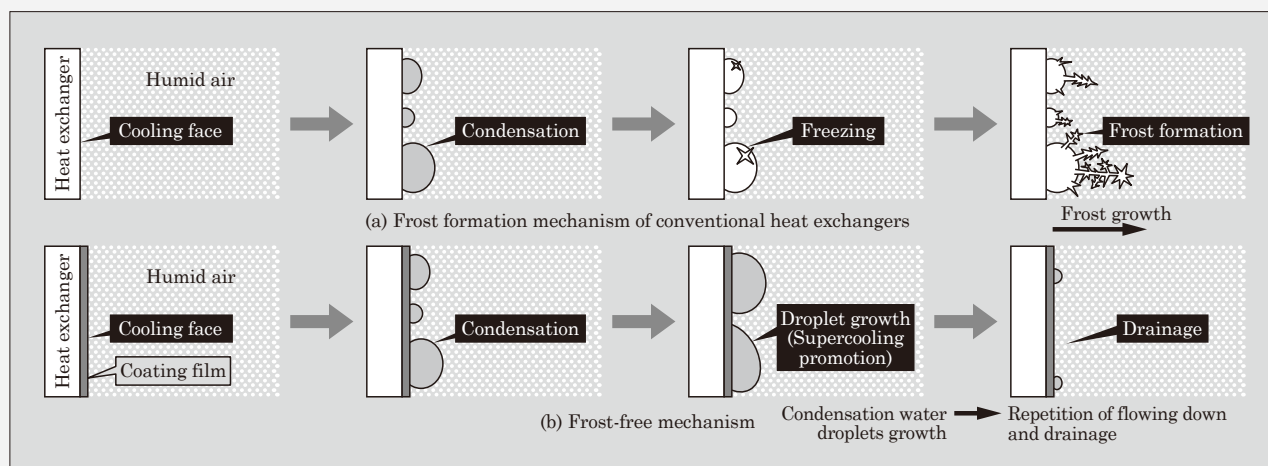


Fig.9 Mechanism of frost-free technology

the equipment. Water in the air condenses on the surfaces of heat exchangers that become cold during operation, which, if cooled below 0°C, freezes and develops into frost, reducing the efficiency of heat exchange. In the past, defrosting was performed, for example, by heating the heat exchanger surface with a heater, which required extra energy.

Figure 9 shows the mechanism of frost formation prevention. Application of a specific material to the surface of the heat exchanger functions to accelerate supercooling (which hinders the action of ice nuclei, which are the starting points for freezing) and the condensed moisture grows without freezing and runs off under its own weight, preventing frost from forming. We are working on the research and development of technologies that eliminate the need for energy used for defrosting, which has been necessary to date, to further improve the energy-efficiency of showcases and vending machines (refer to “Frost-Free Technology for Heat Exchangers Using Functional Coating” on page 149).

5. Postscript

This paper has presented the current status and future outlook of Fuji Electric's effort to create new value in the food distribution field. The market environment will continue to change at a faster pace, and emphasis will be placed globally on environmentally friendly management.

We will continue to improve the core technologies for food distribution—thermal technology, mechatronics and IoT—to respond quickly to these market changes and provide new value.

References

- (1) Katayama, S. et al. Vending Machine Operation Service Using IoT and AI to Increase Operational Efficiency. FUJI ELECTRIC REVIEW. 2021, vol.67, no.3, p.149-154.





* All brand names and product names in this journal might be trademarks or registered trademarks of their respective companies.