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Abstract. In grocery stores, spatial coordination and refrigerated display cases interact, making it difficult to study energy conservation through architectural ideas. The purpose of this research is to find the indoor enthalpy from the leaked heat of the display case and the space conditioning load, and to devise a method to calculate the energy of the store by combining the space conditioning load calculation and the refrigeration load calculation. In this study, we devised the following three points. 1. Store cooling load prediction method and power consumption calculation method using display case cooling load characteristics. 2. A generalized model for grocery store vertical temperature gradient using CFD analysis results. 3. Energy consumption calculation method considering the balance of the three loads of cooling, building and space conditioning. Then, we confirmed the validity by comparing with the measured values, and performed simulations under various conditions.

1 Introduction

From changes in Japan's final energy consumption, the overall increase rate from 1973 to 2013 was 1.2 times. However in the business sector, the increase is remarkable at 2.4 times [1], so that energy saving is required. Manufacturers are actively developing energy-saving equipment for space-conditioning and lighting, which are typical energy-consuming equipment for business use. On the other hand, refrigeration equipment with a high energy consumption density is exposed to cost competition in the food store industry, so that energy-saving equipment is slow to spread. Therefore, it is important to save energy by devising operation and design.

From the advantage of easy to get products, many open display cases (Hereafter indicated as DC) are installed in food stores. The open DC maintains the internal temperature with the air curtain, but from a part of the air curtain cold air in the refrigerator leaks from the DC and the surrounding air enters the DC. Leaked cold air stays in the lower part of the store, affects the air enthalpy in the store and worsens comfort. At the same time, air enthalpy entering DC affects the DC refrigeration load. For these reasons, the load of the open type display case interacts with the space conditioning load, making it difficult to consider energy saving.

There have been many reports on energy conservation in food stores. Narumi created a prediction formula from the store's actual measurement data and calculated the energy saving effect when the DC type was changed or when the store's environmental temperature was changed [2]. CFD analysis is effective to examine the effects of space conditioning and ventilation on store energy savings in detail [3], on the other hand the CFD analysis’s cost is high, it is also important to develop the method that can be easily calculated.

In the work presented in this paper, the relationship between enthalpy characteristics and refrigeration characteristics of five typical refrigerated DC in a grocery store was clarified through experiments. Based on the results, an energy saving calculation method was devised that takes into account the interaction between the space conditioning load and the refrigeration load. Using the devised method, we calculated the annual power consumption of the store's refrigeration and space conditioning.

2 Outline of calculation Introduction

Since display case power consumption is greatly affected by environmental enthalpy, it is important to adjust the enthalpy in the store by space conditioning and ventilation. Combining with space-conditioning load calculation and DC load calculation (refrigeration load regression formula), we calculated annual space-conditioning and DC power consumption at food stores. Fig. 1 shows the calculation flow.

3 Energy consumption calculation for refrigeration

3.1 Refrigeration load calculation

The refrigeration load is calculated under arbitrary ambient temperature and humidity conditions by expressing the DC cooling characteristics of the experimental results [4] as a regression model. In this study, we calculated the refrigeration load per hour. Immediately after defrosting, the temperature inside the
Fig. 1. Energy consumption calculation method

refrigerator rises, so the cooling load increases to cool the inside of the DC. Since the solenoid valve of the refrigerant is closed during defrosting, the load becomes 0, and the cycle of increasing the load at start-up after defrosting is repeated. In addition, in the cooling load calculation of this model, within one hour including defrosting, the time when the load due to defrosting becomes 0 and the load increase due to re-cooling are calculated together.

The coefficients of the multistage refrigeration load prediction formula are shown in the previous report [5].

3.2 Power consumption calculation

Various parameters are required to calculate the power consumption from the refrigeration load. In this study, (1) COP change due to evaporation temperature determined from display case preset temperature, (2) COP outside air temperature correction, and (3) refrigeration capacity decrease correction due to pipe length were formulated from manufacturer catalog values. In addition, a correction was made to increase the evaporation temperature when the display case load is small.

In order to confirm the validity of the calculation, the calculated value of the refrigerator power consumption was compared with the actual measurement value using the refrigeration load calculation and the refrigerator power consumption calculation method described above. The enthalpy of the store air which is used for the calculation, are the measured values on August 24, 2017. Table 1 shows the calculation conditions, and Fig. 2 shows the calculation results. It was almost reproduced the load drop and the power consumption at night due to defrost.

4 Vertical temperature distribution of the store

4.1 Store CFD model

For the store model analysed in this research, the layout and equipment of a typical small-scale food retail store of 261m² were constructed with reference to an existing store. Details of the model are given in the previous report [3].

4.2 Calculation condition

In order to analyse the formation of the store temperature distribution, sensitivity analysis was performed on the relationship between the vertical temperature distributions in the store, the preset temperature of the space conditioner. Table 2 shows the calculation conditions for space conditioning. There are four space conditioning temperature settings: 20°C, 23°C, 26°C, and 29°C.

Table 1. DC and refrigerator specifications

<table>
<thead>
<tr>
<th>System</th>
<th>DC type</th>
<th>DC Width (m)</th>
<th>Preset temperature (°C)</th>
<th>Tev (°C)</th>
<th>Refrigerator rated power (kW)</th>
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<td>7</td>
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<td></td>
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<td>-40</td>
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</tr>
<tr>
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<td>RI(FR)</td>
<td>11.3</td>
<td>-3<del>1</del>1</td>
<td>-40</td>
<td>23</td>
</tr>
</tbody>
</table>

※1 MD(RE) : an open refrigerated multi-deck display case
SMD(RE): an open refrigerated semi multi-deck display case
TUB(RE): a refrigerated tub display case
TUB(FR): a frozen tub display case
RI(RE): a refrigerated glass door reach-in display case
RI(FR): a frozen glass door reach-in display case
Tev (°C): Evaporating Temperature

Fig.2. Refrigerator power consumption prediction for model store

(a) Calculated based on outside air temperature on Aug. 24, 2017

(b) Measured value on Aug. 24, 2017
23°C for heating and 20°C, 23°C for cooling. The disturbance is given by increasing the air volume of space conditioning, and there are three conditions of 1 times the standard, 1.5 times the standard, and 2.0 times the standard. The standard air volume for cooling was set to be about a weak wind (air volume: 0.35m³/s), and the standard air volume for heating was set to be about a strong wind (air volume: 0.60m³/s) so that warm air reaches the floor surface.

### 4.3 Vertical temperature distribution model inside the store

Based on the calculation results of the vertical temperature distribution in the store, we devised a summer model as shown in Fig. 3. The space conditioner load (cooling) \( Q_{ac} \) and DC leakage heat \( Q_{scl} \), which balance the building load \( Loads_b \), are divided into a completely mixed portion \( Q_{mix} \) that mixes up to the building ceiling and an unmixed portion \( Q_d \) that accumulates cold air at a certain rate below. In order to incorporate the vertical temperature distribution in the store into the calculation, it is necessary to generalize the load distribution. Therefore, assuming that the vertical temperature distribution is approximately equal to the load distribution, the temperature difference from the temperature near the ceiling was calculated in 0.1m increments, and the load distribution ratio to the whole was arranged. The CFD calculation model store had a ceiling height of 2.7m, and the actual measurement model store had a ceiling height of 4.0m. Therefore, the distribution of 2.2m to 2.7m in the CFD calculation results was expanded to the distribution of 2.2m to 4.0m. As shown in Fig. 4, the distribution ratio showed the same tendency even if the temperature before space conditioning and the disturbance conditions were different, so these average values were used as the distribution ratio model. The vertical mixing ratio, which is the ratio of the load \( Q_{mix} \) that completely mixes up to the ceiling in the building load \( Loads_b \), is 23°C: 26%, 20°C: 37% for air volume I, and 23°C: 56%, 20°C: 60% for air volume III. When the preset temperature is low and the air volume is large (the disturbance is large), \( Q_{mix} \) becomes large. That is, as the vertical mixing ratio \( Mix \) increases, the vertical distribution decreases. It shows that the unmixed fractions are distributed similarly regardless of the magnitude of the disturbance. The relationship between \( Loads_b \), \( Q_{ac} \), \( Q_{scl} \), \( Q_{mix} \), and \( Q_d \) and the definition of \( Mix \) are shown below.

\[
\begin{align*}
    Load_b &= Q_{ac} + Q_{scl} \quad (1) \\
    Load_b &= Q_{mix} + Q_d \quad (2) \\
    Mix &= \frac{Q_{mix}}{Q_{ac} + Q_{scl}} \quad (\text{in summer}) \quad (3) \\
    Mix &= \frac{Q_{mix}}{Q_{scl}} \quad (\text{in winter}) \quad (4)
\end{align*}
\]

\( Load_b \) kW  Building space conditioning load (total heat)
\( Q_{ac} \) kW  Space-conditioning processing load shared by space-conditioning equipment
\( Q_{scl} \) kW  Leakage heat from the DC
\( Q_{mix} \) kW  Building space conditioning load mixed vertically
\( Q_d \) kW  Building space conditioning load that does not mix vertically and has a distribution from top to bottom
\( Mix \)  Ratio of load that mixes perfectly in the vertical direction to the space conditioning load of the building

Fig. 5 shows the winter model. Unlike in summer, the sum of the building load \( Loads_b \) and the DC leakage heat \( Q_{scl} \) is the space conditioner load (heating) \( Q_{ac} \).

Fig. 6 shows the load distribution ratio for each condition in winter. Since the wind volume is larger than in summer, the distribution is linear, but the overall trend is the same. These average values were used as the load distribution ratio model in winter.
5 Power consumption calculation

5.1 Summary of calculation method

Fig. 7 shows a balance diagram (cooling) of in-store enthalpy, space conditioning load, and heat leakage from DC under a constant outside temperature condition. When the in-store enthalpy increases, the refrigeration load of the DC increases, and accordingly the heat leakage from the DC increases. On the other hand, as the in-store enthalpy increases, the building (cooling) load decreases. The point where these are balanced is the enthalpy in the store.

Therefore, the space conditioning does not operate unless the pre-setting of the space conditioning is equal to or lower than the balanced in-store temperature. When the space conditioning is operated so that the temperature in the store is kept below the balanced temperature, the enthalpy of air flowing into the DC is determined by the vertical temperature and humidity distribution at that time, which determines the refrigeration load of the DC.

Accordingly, the amount of heat leaked from the DC is determined, and the amount of heat obtained by subtracting the amount of heat leaked from the building load becomes the space conditioner load. Power consumption is calculated by dividing the space conditioning load and DC refrigeration load by their efficiency. In the calculation, the refrigeration load is obtained from the enthalpy of LF1200mm and distributed to 40 layers from the floor to the ceiling using the distribution ratio. Determine the enthalpy of each layer so that they balance with the building heat load. In other words, the in-store enthalpy in Fig. 7 refers to the enthalpy averaged for each layer in each in-store area, which will be described later.

Table 3 Space conditioning load calculation conditions

<table>
<thead>
<tr>
<th>Software</th>
<th>BEST program (Thermal load calculation function) (Professional Edition Ver.1810)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather data</td>
<td>Extended AMEDAS (2010 edition) standard year Nagoya</td>
</tr>
<tr>
<td>Sales floor area</td>
<td>2172m² (Left : 479.7m² Center : 1134.6m²)</td>
</tr>
<tr>
<td>Floor height</td>
<td>5.6m (Ceiling height 4.0m)</td>
</tr>
<tr>
<td>Coefficient of overall heat transmission</td>
<td>Outer wall 1.26W/m² · K</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Ventilation frequency 1 time / hour</td>
</tr>
<tr>
<td>Space conditioning operating time</td>
<td>7:00～21:00</td>
</tr>
</tbody>
</table>

Fig.6. Comparison of load distribution ratio for each space conditioning condition (Qd) (winter)

Fig.7. Relationship between store space conditioning load and DC leakage heat (summer)

5.2 Overview of model stores

5.2.1 Building conditions

To calculate power consumption, it is necessary to calculate the space conditioning load of the store. Table 3 shows the space conditioning load calculation conditions for the model store used in the calculation. The store has a sales floor area of 2,172 m² and a ceiling height of 4 m, which is larger than a general food retail store, and the back side of the store is less affected by the outside air. Ventilation was operated for 24 hours, and the ventilation volume was set to once per hour. Ventilation volume from the gap was set at 800m³/h, which is equivalent to 0.1 ventilation. A pattern was created for the lighting load based on actual measurement data, and 6W/m² was used as the basic unit calculated from the actual measurement of the maximum power consumption of 13kW. The internal equipment heat generation pattern was also created from the measurement results, and the internal equipment heat generation maximum value was 9.1 kW, and the basic unit was 4.2 W/m². Based on an interview with the manager of this store, the personnel heat load was created from 2,000 visitors/day on weekdays and 2,400 visitors/day on weekends, and 25 minutes/person in the store. The pattern was created with reference to the
"supermarket sales floor" of the product sales store under the Building Energy Conservation Law [6]. The basic unit of personnel density was set at 0.07 person/m².

5.2.2 DC conditions

The DC consists of 6 systems of refrigerators, and the types and lengths shown in Table 1 are installed. A night cover is installed in the DC at night, and it is assumed that there is a night setback that raises the set temperature of the refrigeration system. As shown in Fig. 8, DC is a typical store format in which stores are arranged in a U-shape around the store.

5.3 Method of calculation

5.3.1 Area division method, "area retention rate" and "vertical mixing rate" of DC leakage heat

In Chapter 4, we devised a model for the distribution of the unmixed component, excluding the completely vertical mixed component, for the vertical distribution. DC equipment is unevenly distributed in real stores, and many non-cooled fixtures are installed, so DC leakage heat stays in some areas. Therefore, it is necessary to consider the horizontal temperature distribution in addition to the vertical temperature distribution. In this section, we examined the division of areas based on the results of horizontal and vertical temperature distribution measurements conducted during the interim period. Measurements were taken in the morning (10:00-11:30) and afternoon (14:30-16:00) on November 30, 2017.

Based on the actual measurement results, the area was divided into three areas shown in Fig. 8, and calculations were performed assuming horizontal mixing and vertical mixing. These three areas affect adjacent areas. Therefore, it is assumed that the DC leakage heat flows from the left and right areas where the DC is concentrated to the central area where the DC is not installed. Here, the area retention rate is defined as a ratio obtained by dividing the "DC leakage heat staying in the area" by the "total leakage cooling amount of the DC installed in the area". For example, a calculation method will be described below assuming that the retention rate in the left area is 60% and the retention rate in the right area is 70%. DC leakage heat in the left area is calculated by the temperature and humidity of FL1200mm, and 60% of DC leakage heat is used for heat balance calculation with building heat load. Similarly, for the right area, a value obtained by multiplying the DC leakage heat by 70% is used for the heat balance calculation. 40% of the DC leakage heat that does not stay in the left area and 30% of the DC leakage heat that does not stay in the right area are added to the DC leakage heat in the middle area to calculate the heat balance. Adjust the retention rate of the left area and the right area, and the area retention rate that takes a value close to the actual measurement data is 75% in the left area. A right area of 60% was assumed. Fig. 9 shows the measured results and calculated results. Although there are differences in the vertical distribution, the temperature near the floor surface, the temperature near the ceiling, and the temperature difference between areas are reproduced. These vertical mixing ratios and area retention ratios are assumed values based on the results of actual measurements during the interim period, and are considered to change depending on the season. Although the values were not optimized in this study, hypothetical values were set for the purpose of evaluating the calculation method given the vertical temperature distribution for each area in this paper. It is positioned as a future task to examine how to give the vertical mixing ratio and area retention ratio when space conditioning is in operation and when different store formats are targeted.

Fig.8. Store layout and area division

(a) Area retention rate          (b) Actual measurement results
(L=75%  R=60%)  Mix=80%        November 30, 2017

Fig.9. Comparison of measured and calculated results of vertical temperature distribution (average for each area)

5.3.2 Calculation of heat load and power consumption

First, determine the type and number of DCs in the store, and create a store comprehensive characteristic formula (latent heat/sensible heat) related to DC by synthesizing each DC characteristic. When calculating the balance point between DC leakage heat and store building load, it is necessary to repeat the space conditioning load calculation frequently. In this calculation method, in order to easily link with the space conditioning heat load calculation by BEST (heat load calculation software), the space conditioning preset 4 to 32°C, absolute humidity 0.00132 to 0.01424kg/kg for one year building heat load calculations. After that, a data frame
was created by linearly interpolating the absolute humidity of 0.0001 kg/kg and the temperature in 0.1°C increments. By simply adjusting the building load obtained at each point of the vertical temperature distribution in increments of 0.1m, the space conditioning load when there is a vertical temperature distribution can be easily calculated. In addition, in the actual store during closing hours, products may be stored in a large refrigerator and the DC may be stopped, so the load was set at 60% of the DC characteristics (night-time setting) in the calculation. Using the load distribution ratio created in Chapter 4, the inflow temperature $T_{12}$ to DC is determined so that the building load and DC leakage heat are balanced. Next, $T_{mix}$ (vertical complete mixing temperature) is calculated backward from the complete mixing ratio, and if $T_{mix}$ is higher than the space conditioning preset temperature (in the case of cooling), the space conditioning load is calculated. In the case of heating, when $T_{mix}$ is lower than $T_{ac}$, the space conditioning operates, and $Q_{act}$ is added to the space conditioning load. The latent heat was calculated similarly. Calculations were performed using the statistical analysis software "R Studio", which facilitates handling of data frames. Refrigeration power consumption was calculated by the method shown in 3.2. The power consumption required for space conditioning was calculated by assuming that there is no unprocessed load, all space conditioning loads are processed by the space conditioner, and that the rated COP for both cooling and heating is 3.5 (with outside temperature correction).

5.4 Method of calculation

5.4.1 Comparison of actual and calculated values

In order to compare the observed and calculated values, we selected the observed date similar to the standard meteorological data. Table 4 shows the calculation conditions for the selected target days. The vertical mixing rate Mix is assumed to be 80%, and the area retention rate Stay is assumed to be 75% in the left area and 60% in the right area as described in 5.3.1.

5.4.2 Calculation result

The power consumption of the DC refrigerator and space conditioner outdoor unit, the temperature of the outside space, the vicinity of the ceiling, and the FL 1200mm were compared between the measured values and the calculated values. The space conditioning preset was set to 26°C60%, which is the same as the actual measurement. Fig. 10 shows the comparison results in summer, and Fig. 11 shows the comparison results in winter. The measured temperature and humidity in the store show the average temperature at 4 points near the ceiling and 4 points at a height of 1.2m in the model store. The temperature of FL1200mm is calculated lower than the actual measurement value, and accordingly the power consumption of the refrigerator is small and the space conditioning power consumption is calculated large. Compared to the actual measurement, the sharing of the space conditioning load is slightly larger, so in the comparison of the total power consumption of the refrigerator and space conditioning (total value from 10:00 to 19:00 when operation is stable), the calculated value is lower than the actual measurement. -7.6%, -130kWh, slightly smaller. In winter, the space conditioning operation time was calculated from 9:00 to 20:00 according to the actual measurement. In the winter night-time calculation, the amount of heat leaked from the DC becomes smaller, and at the same time the building cooling load of the store becomes smaller, so it is difficult to find the balance temperature. At the actual store, the temperature does not fall below 10°C even at night. So, if the FL1200mm temperature calculation result drops by 10°C, the calculation is stopped and the temperature is set at 10°C. In winter, the temperature of FL1200mm is calculated slightly higher than the measured value, and accordingly the power consumption of the DC refrigerator is also calculated slightly higher. DC

<table>
<thead>
<tr>
<th>CASE</th>
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<th>Space conditioning preset temperature / humidity</th>
<th>Mix/Stay</th>
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<tr>
<td>8-4-26-60</td>
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Fig.10. Comparison of actual measurement and calculation (summer)
leakage heat also increases accordingly, but since the store enthalpy is low in winter, there is almost no increase in heating load. In addition, the actual measured value of the outside space temperature is about 2°C higher, and the measured value of the heating power consumption is slightly smaller than the calculated value. As a result, when comparing the total power consumption of refrigerators and space conditioners (total value from 10:00 to 19:00 when operation is stable), the calculated value is 4.8%, or +38 kWh, slightly larger than the measured value. Although there is a problem in setting the vertical mixing ratio, which is an important parameter, we have devised a calculation method that can explain the relationship between air conditioning and refrigeration.

6 Various simulations

6.1 Annual power consumption calculation

Fig. 12 and Fig. 13 show changes in average daily power consumption for 12 months. Fig. 14 shows a comparison of annual total power consumption. Looking at the August average of space-conditioning power consumption in the summer, with a preset temperature of 22°C, the maximum is 366kWh/day, which decreases as the preset temperature rises, and reaches 79kWh/day with a preset temperature of 28°C. The refrigerator power consumption increased by 180kWh to 1608kWh/day with the 22°C preset and 1787kWh/day with the 28°C preset setting. The total decreased slightly from 1914kWh/day at 22°C preset to 1866kWh/day at 28°C preset. Comparing the January average of space conditioning power consumption in winter, it is 452kWh/day with the preset temperature of 22°C, and 346kWh/day with the preset temperature of 19°C. The average daily power consumption of refrigerators in January decreases to 886kWh/day with the 22°C preset and 766kWh/day with the 19°C preset. The total power consumption for space conditioning and refrigeration decreased from 1248kWh/day to 1112kWh/day, a decrease of 136kWh/day (approximately 11%). This trend did not change throughout the winter period from December to March, and it was found that lowering the heating setting to the extent that comfort permits is an energy-saving operation. Comparing the annual load in each case, the annual power consumption is greatly affected by the decrease in the preset temperature in winter. 452.8MWh/year at 19°C (winter) and 28°C C60% (summer) when the baseline is 471.8 MWh/year at 22°C (winter) and 25°C C60% (summer) MWh/year was the lowest, and the annual power consumption reduction amounted to 19MWh/year (4%).

6.2 Relationship between store enthalpy and power consumption of refrigerators and space conditioners in summer

In 6.1, we evaluated the energy saving effect by changing the space conditioning presets for the year. However, these are the effects when the preset temperature of the space conditioning is fixed and operated. Whether it is more energy efficient to actively
operate the space conditioning depends on the heat load of the refrigeration and space conditioning and the COP of each device at that time. In other words, it is considered that the optimal space conditioning preset temperature changes depending on the outside air temperature. As shown in Fig. 7, the refrigerator power consumption is determined by the magnitude of DC leakage heat, that is, the enthalpy of the inside space and the outside air temperature. Space conditioning power consumption is strongly influenced by the enthalpy inside the store and the outside air temperature. If these relationships can be considered, a suitable space conditioning operation method for each outside air temperature can be determined.

From the annual calculation results for summer, data with similar outdoor temperatures were extracted, and regression equations were created for the indoor enthalpy, space conditioning power consumption, and refrigerator power consumption for each temperature. Fig. 15 shows the relationship between in-store enthalpy and the total power consumption for refrigeration and space conditioning by outside temperature.

The amount of energy saved when the in-store enthalpy of the total power consumption of refrigeration and space conditioning is reduced differs in the rate of

![Graph: Relationship between in-store enthalpy and total power consumption for refrigeration and space conditioning (summer)](image)

1. When the space conditioning operation was fixed in summer and winter in a large-scale model store, the space conditioning setting of 19°C in winter and 28°C60% in summer resulted in the lowest power consumption.
2. In winter, the lower the enthalpy inside the store, the more energy is saved regardless of the outside air temperature.
3. When the summer outside temperature is 30°C or higher, there is almost no effect of active use of space conditioning. When the outside temperature is 27°C, there is an energy saving effect of 15% when the space conditioning is set to 22°C60% compared to when there is no space conditioning. Energy-saving effects can be expected if the space conditioning can be finely controlled during times when the outside air temperature is low. However, it is necessary to consider comfort.

7 Conclusion

In this report, annual calculation results of the power consumption of space conditioners and refrigerators when the space conditioner set temperature is fixed and operated using a calculation method that considers the cooling and space conditioning load balance are presented. In addition, using the results, we analyzed the relationship between refrigerator power consumption, space conditioning power consumption, enthalpy inside the store, and outside air temperature, and obtained the following knowledge.

1) When the space conditioning operation was fixed in summer and winter in a large-scale model store, the space conditioning setting of 19°C in winter and 28°C60% in summer resulted in the lowest power consumption.
2) In winter, the lower the enthalpy inside the store, the more energy is saved regardless of the outside air temperature.
3) When the outside air temperature is higher than 30°C, there is almost no effect of active use of space conditioning. When the outside temperature is 27°C, there is an energy saving effect of 15% when the space conditioning is set to 22°C60% compared to when there is no space conditioning. Energy-saving effects can be expected if the space conditioning can be finely controlled during times when the outside air temperature is low. However, it is necessary to consider comfort.

References

6. Technical information on evaluation of energy consumption performance in accordance with the 2016 Energy Conservation Standards (non-residential buildings), Building Research Institute, in Japanese