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VRF on-site Measurement by Compressor Curve Method and Its Application

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1. Background and Purpose of This Study

【Background】Stereotype of VRF from Architectural Side

≒VRF is not suitable for Commissioning (Cx) ?

＜Examples＞

Problems of VRF operation

- Hard to know the VRF performance.
- Tendency to select machines with excessive capacity.

Problems on operation evaluation process

- Large number of VRF equipment should be tested and inspected.

【Purpose】

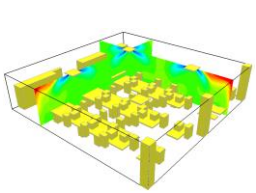
1）Clarify the evaluation criteria and indicators of VRF management for proceeding Cx.

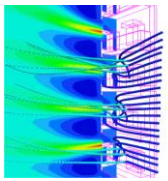
2）Decide the report format and increase the case study of VRF Cx.

2. VRF Cx (1)

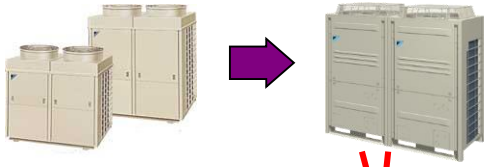
■Techniques for VRF Cx

Air flow simulation



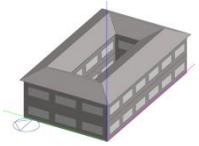


Equipment replacement and repair

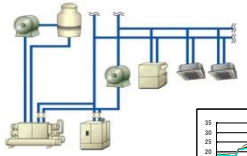


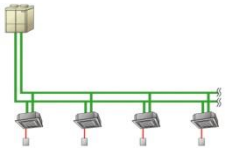
Conception or pre-design → Design → Construction /Installation → Operation → Improvement

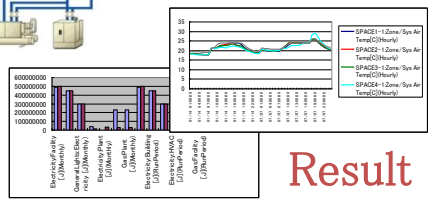
Energy simulation



Model

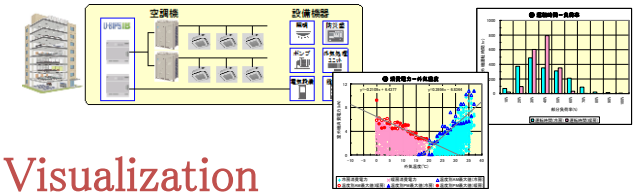




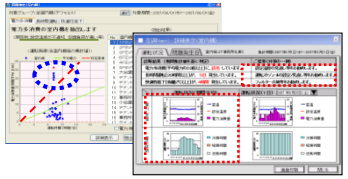


Result

Energy Management



Visualization



Analysis and diagnosis

2. VRF Cx (2)

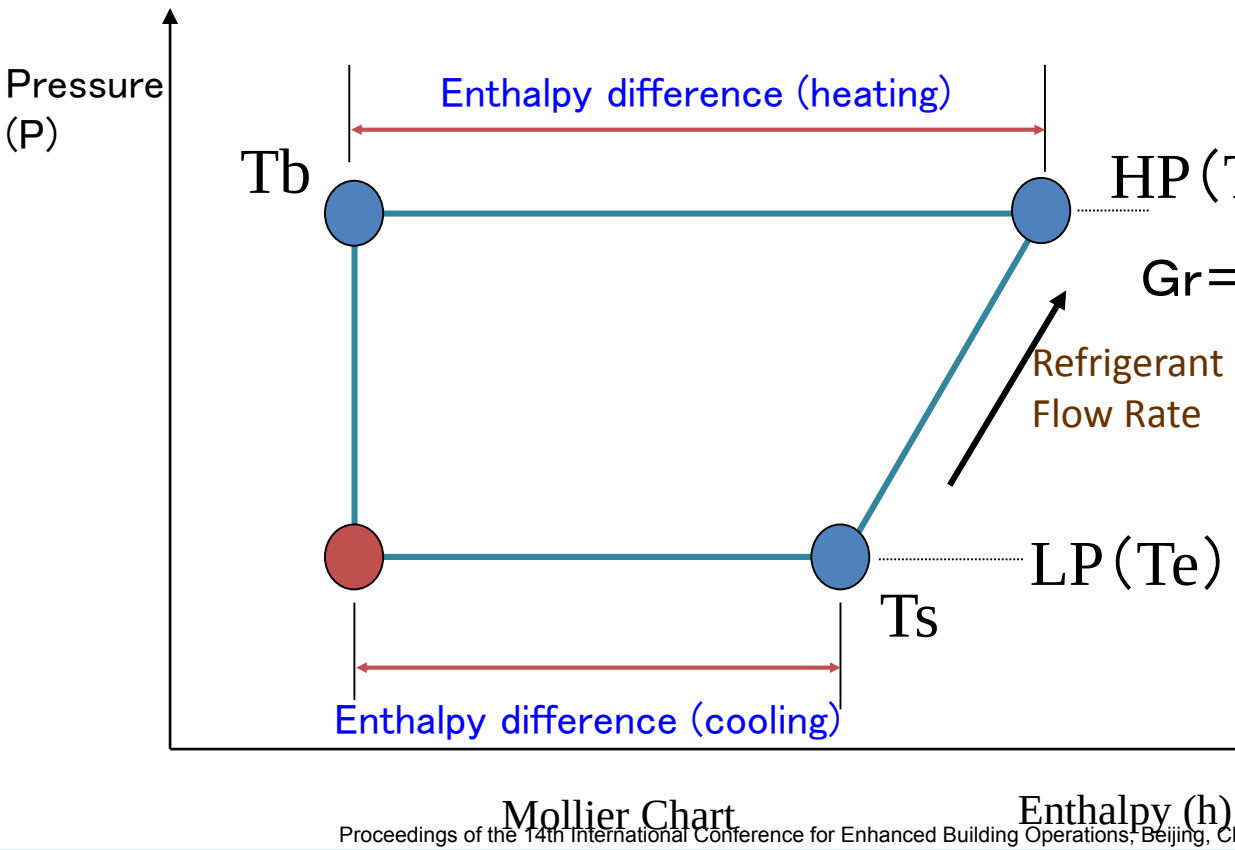
■Indicators and Evaluation Criteria for VRF Management

		Items	Overview and Definition	Management and evaluation content
indicators for VRF management	1	Operation mode（Cooling/Heating）	Changes of Cooling and Heating on the Remote Controller	If the season whether cooling or heating operation is really needed
	2	Operation Time（On/Off）	Remote Controller -On Time	Presence of long time operation
	3	Set Point Temperature	Set Point Temperature on the Remote Controller	Whether the set point temperature is on the appropriate range
	4	Suction Temperature of Each Outdoor Unit	Suction Temperature of Each Outdoor Unit（≒Outside Temperature）	Whether air conditioning is really needed or not
evaluation criteria	1	Suction Temperature of Each Indoor Unit	Suction Temperature of Each Indoor Unit（≒Room Temperature）	Room environment by checking temperature.
	2	Amount of Heat Processed by VRF for Cooling Operation	Amount of Heat Processed by VRF in Each System	Heat processed by VRF
	3	Amount of Heat Processed by VRF for Heating Operation	Amount of Heat Processed by VRF in Each System	Heat processed by VRF
	4	Cooling Load Ratio	Cooling Load/Rated Capacity of Outdoor Units	State of operation
	5	Heating Load Ratio	Heating Load/Rated Capacity of Outdoor Units	State of operation
	6	Operating Time of Indoor Units（Thermo-On Time）	Thermo-On Time of Indoor Units	Presence of the operating time by forgetting to turn off the air conditioning
	7	Operating Time of Outdoor Units（Thermo-On Time）	Thermo-On Time of Outdoor Units	Presence of the operating time by forgetting to turn off the air conditioning
	8	Power Consumption of Indoor Units	The estimated Value of Power Consumption of Indoor Fan	Power consumption
	9	Integral Power Consumption of Outdoor Units（Operating）	Operating Power Consumption	Power consumption
	10	Integral Power Consumption of Outdoor Units（Standby）	Standby Power Consumption	Power consumption
	11	Energy Use Efficiency (Outdoor Units)	Outdoor Units Efficiency (Outdoor Units Operating)	Heat source COP calculation
	12	Energy Use Efficiency (Systems)	System Efficiency（Including Standby, Indoor Units and Outside air treatment）	System COP calculation

3. Compressor Curve Method (1)

Cooling and Heating Capacity(Q)
= Enthalpy Difference(ΔH) × Refrigerant Flow(G)

$$\Delta H = f(Tc, Te, Ts, Tb)$$

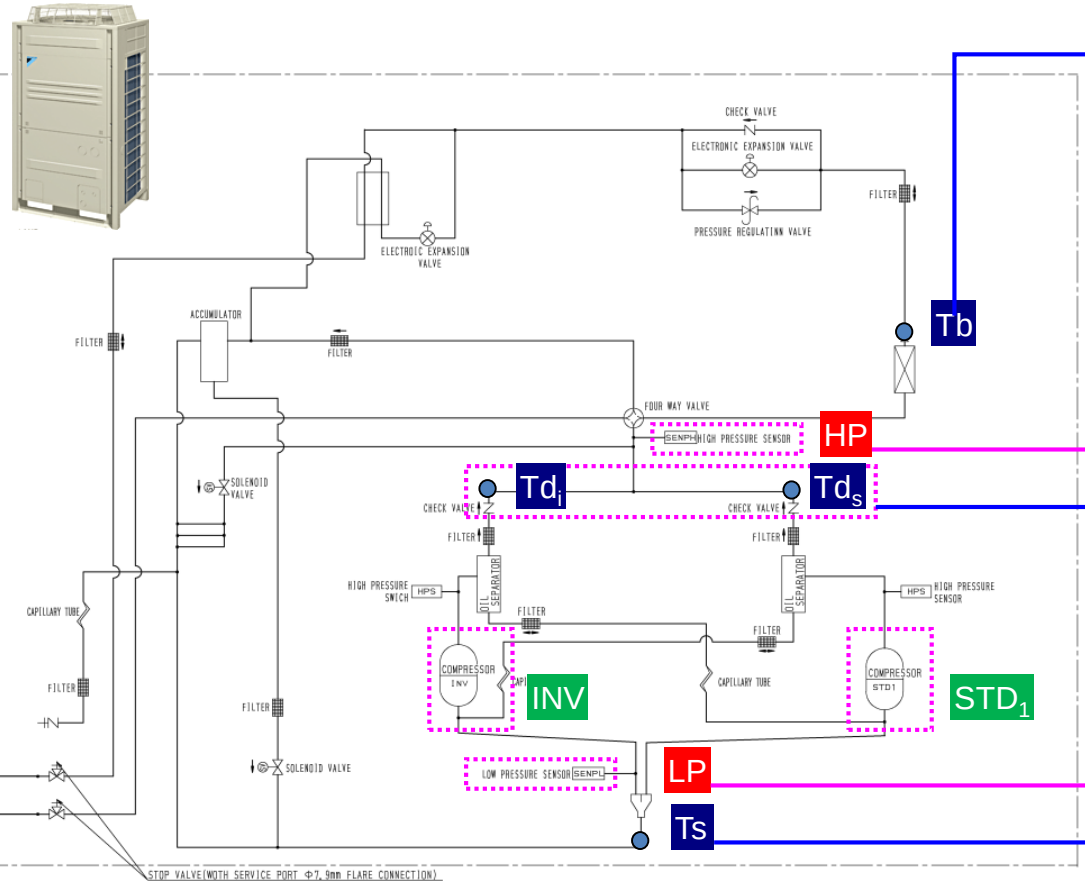


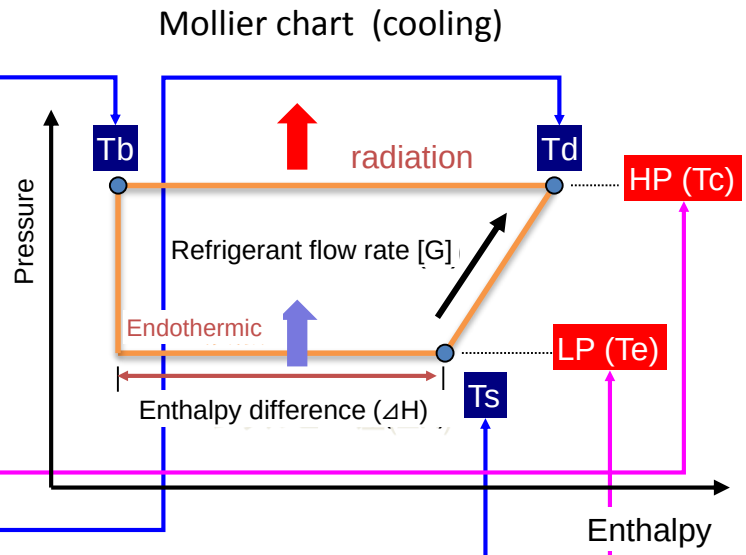
$$Gr = f_{Gr}(Tc, Te, Ts, Frequency)$$

Te: Evaporating pressure equivalent saturation temperature
Tc: Condensing pressure equivalent Saturation temperature
Ts: Compressor suction temperature
Frequency:
Number of rotations of a compressor

3. Compressor Curve Method (2)

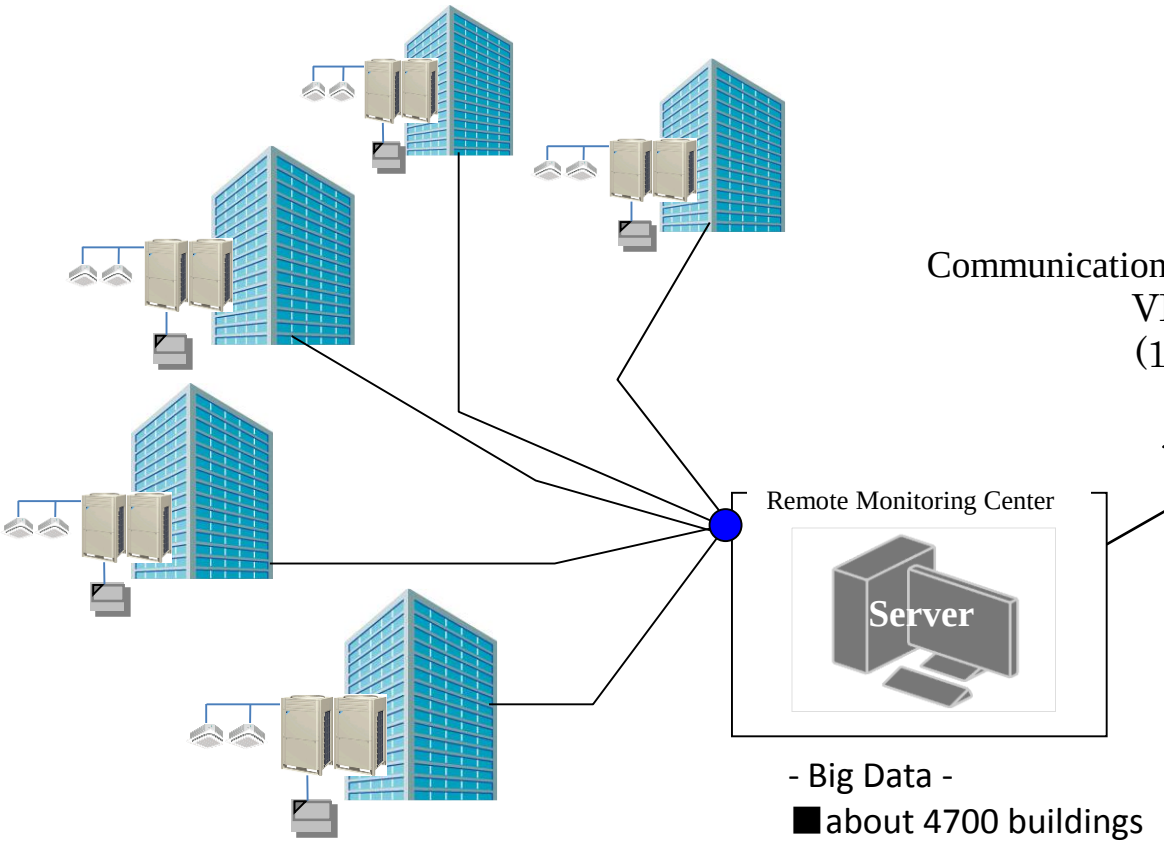
■ Piping diagram and sensor location (the case of a system with 2 compressors)





4. How to Get the VRF Operating Data

■Remote Monitoring system



Communication line :
VRF Operating Data
(1data/day)

Operating data detail analysis

- Big Data -
■about 4700 buildings
■about 40,000 systems

5. Expansion of Cx case study (1)

■Decide the report format of VRF Cx

Ⅰ. Overview of the VRF System
- 1. Construction and layout of the target VRF.
- 2. Total operating time

Ⅱ. Status of Power Use
- 1. Power consumption of the whole building (when building's total consumption is known)
- 2. Evaluation for the operation of VRF

Ⅲ. Floor Comparison of VRF Operation

Ⅳ. VRF Which Needs Operation Improvements or Repair
- 1. Rankings of outdoor units' operating data
- 2. Rankings of indoor units' operating data

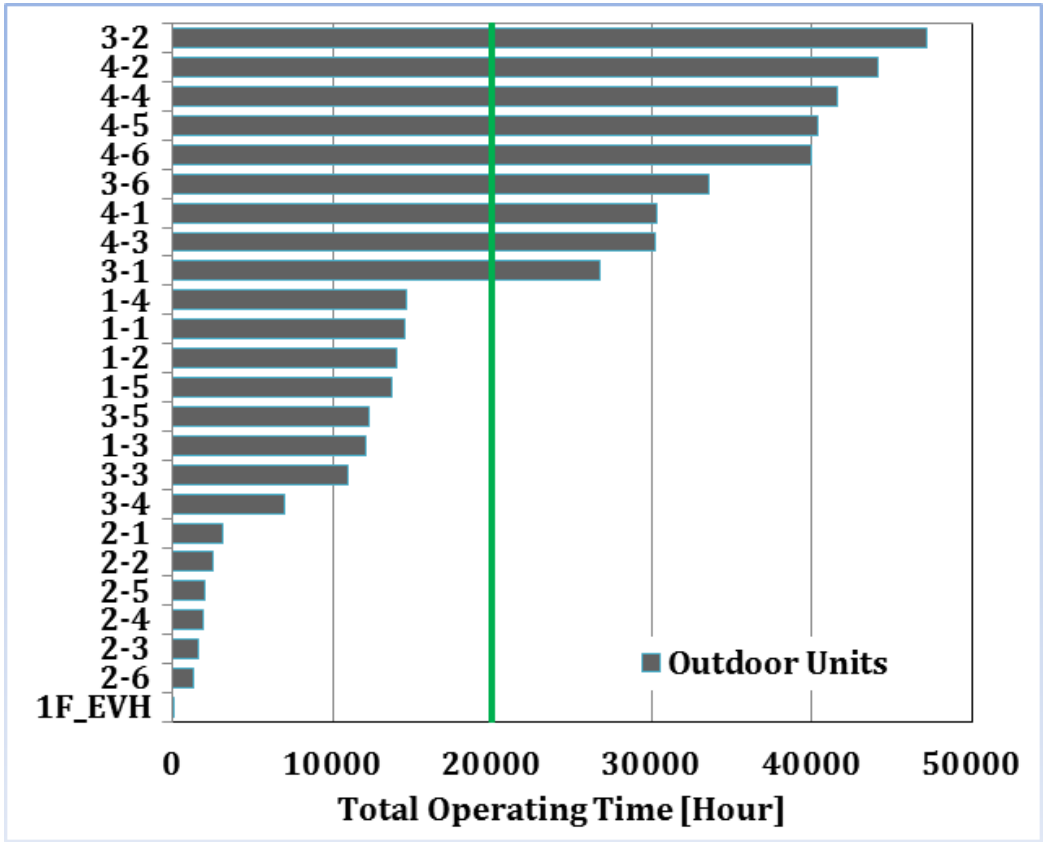
Ⅴ. Detail Analysis of the High Priority Outdoor and Indoor Units

5. Expansion of Cx case study (2)

■Total operating time

[Purpose]

To chose the target equipment which needs maintenance like overhaul.

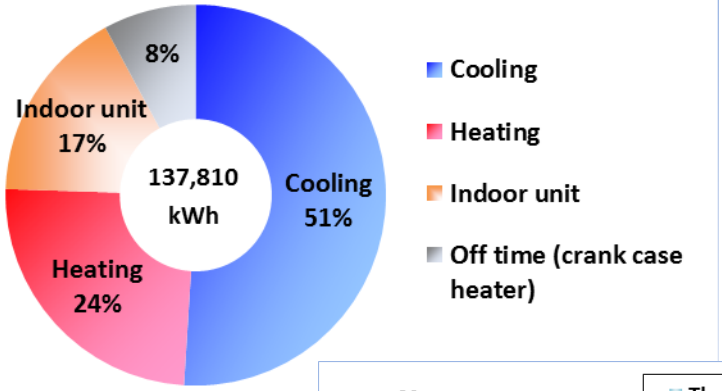


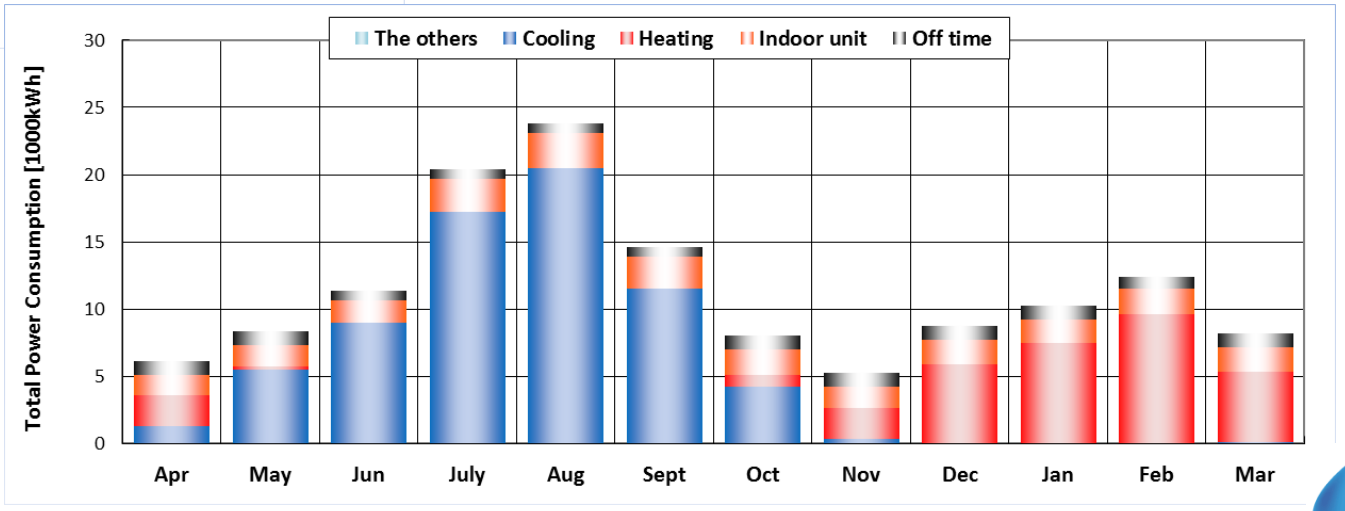
5. Expansion of Cx case study (3)

Breakdown of Monthly Energy Consumption

[Purpose]

To chose which season, cooling or heating, needs improvements.



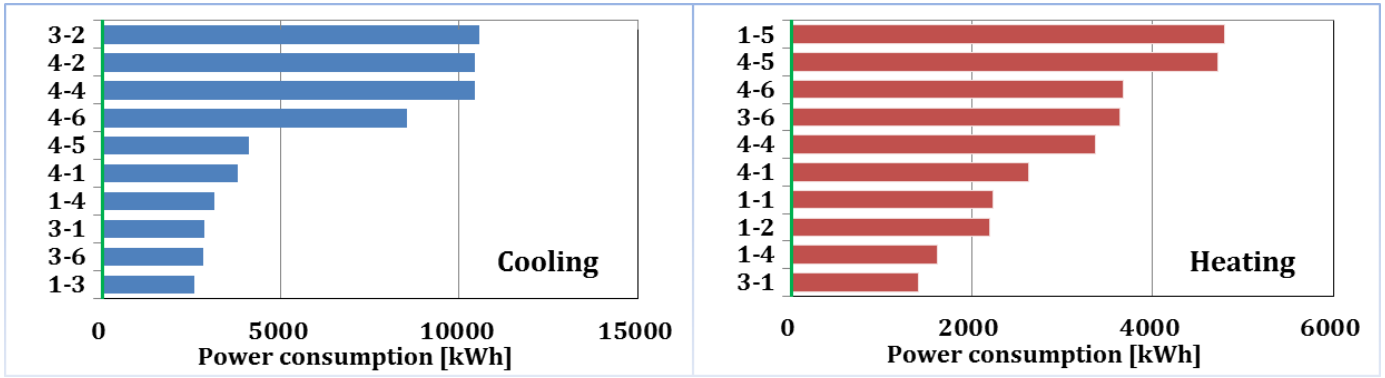


5. Expansion of Cx case study (4)

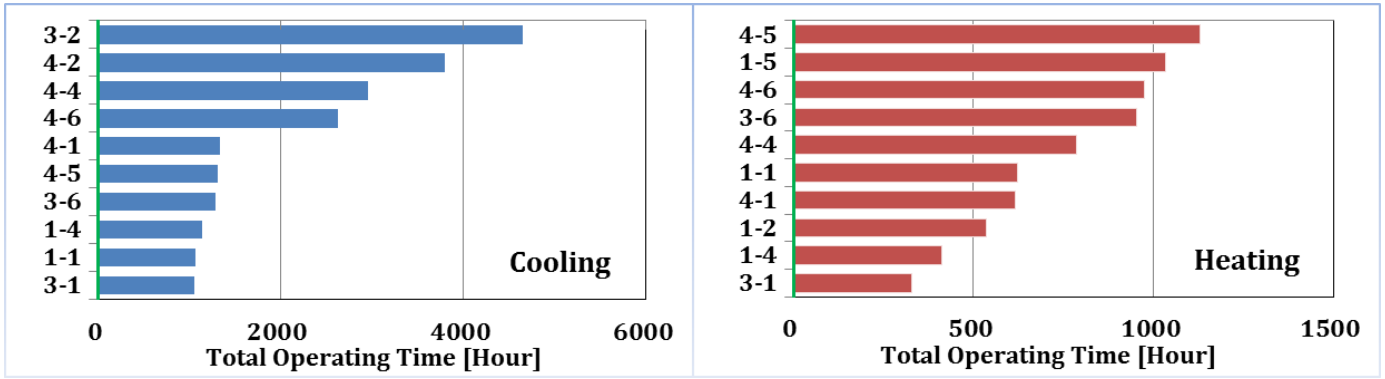
■Rankings of Outdoor Units

[Purpose]

To find the outdoor units which needs more detail analysis



Ex1.) Total power consumption



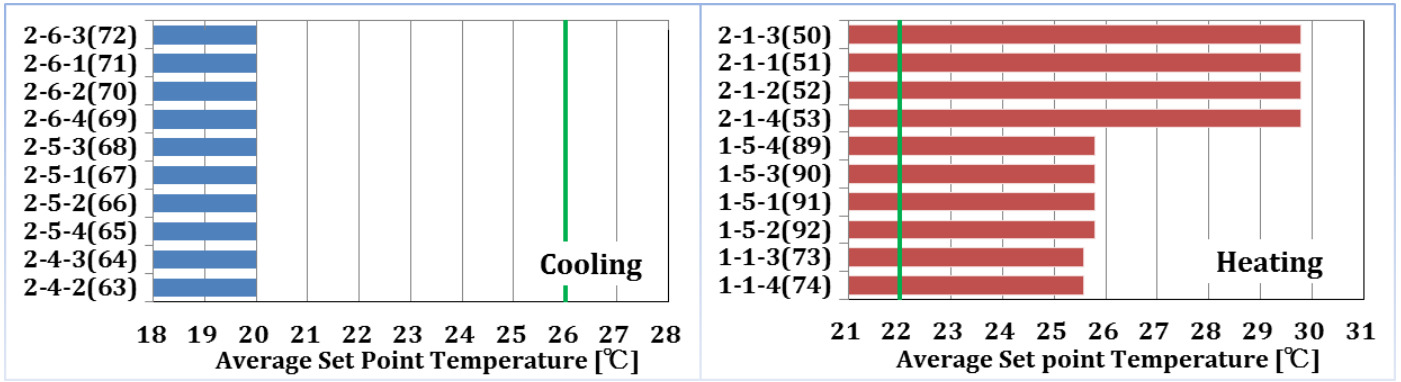
Ex2.) Total operating time

5. Expansion of Cx case study (5)

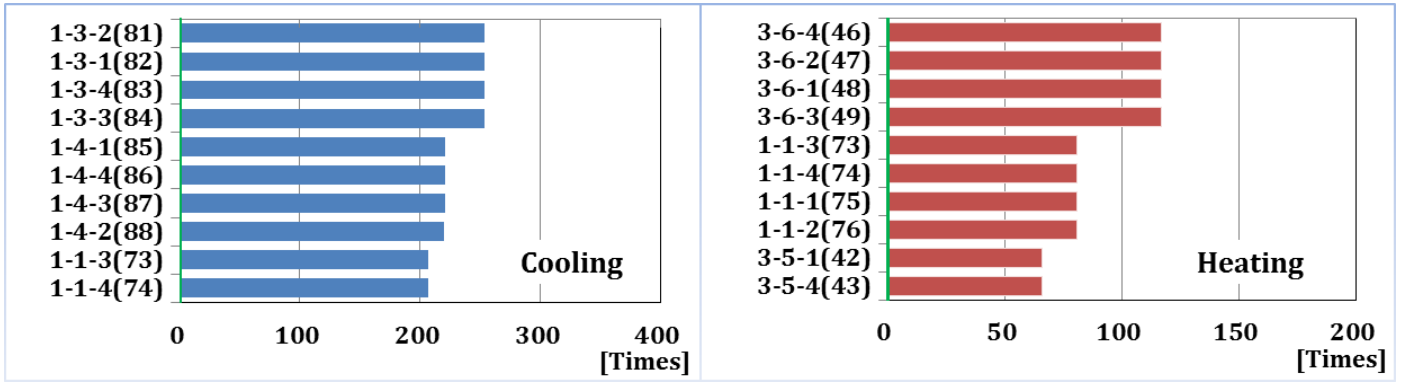
■Rankings of Indoor Units

[Purpose]

To find the indoor units which needs operation improvements



Average set point temperature



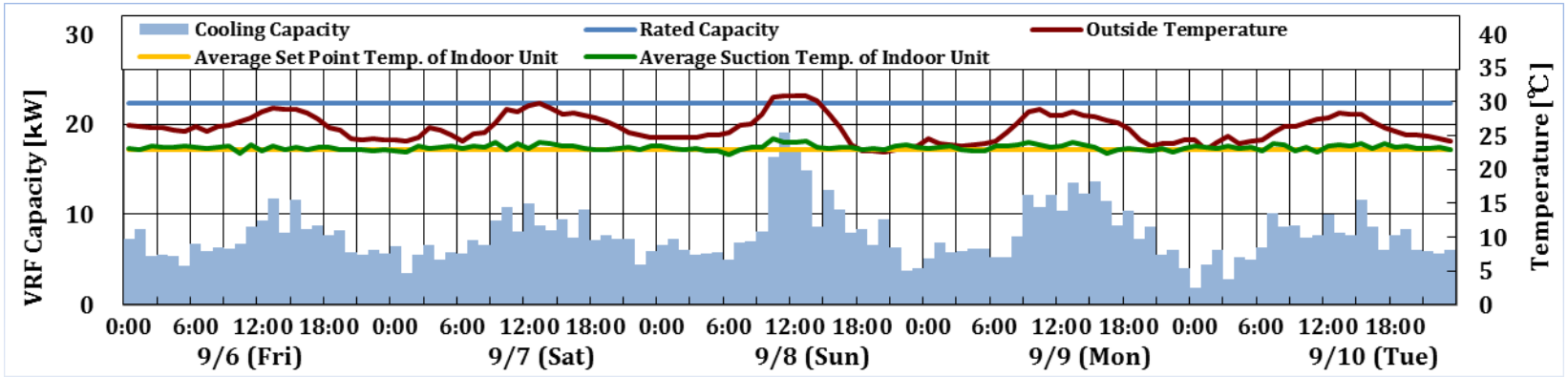
The number of changes for set point temperature

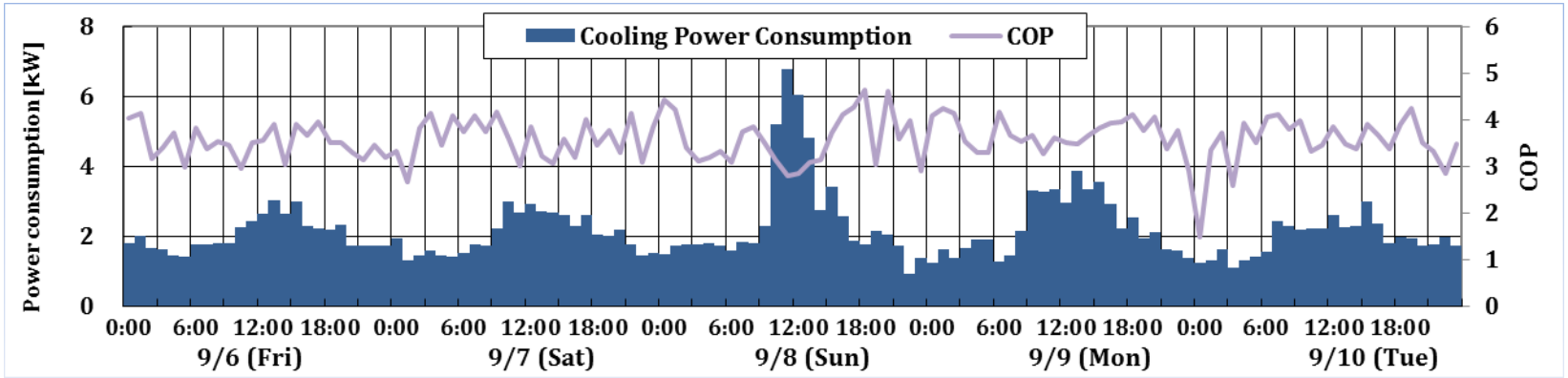
5. Expansion of Cx case study (6)

■Detail analysis of the high priority outdoor unit

[Purpose]

To find the time of peak load and margin of the VRF capacity





Cooling operation of the week which record a peak load

6. Conclusion

VRF is suitable for Commissioning.

Facts appeared through this study.

✓The contribution by the improvements in VRF operation toward the power reduction of the whole building is clarified.

✓The priority of the VRF which needs maintenance is clarified by looking the total operating time.

✓The priority of the VRF which needs improvements is clarified from the ranking data.

✓Indoor units' information from remote controller is useful for operation improvements.

✓The efficiency and the margin of VRF capacity are clarified from the amount of heat processed by VRF.

Thank you for your attention.