CO_2 Transcritical Unit Operating Data in West and South of Japan 2018

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68%of Cold Storages still use R22

- 68% of cold storage still use R22 (volume of cold storage: data Japan Association of Refrigerated Warehouses 2016)
- 90% of cold storage are owned by small or medium size companies
  →need longer time to change R22 to new refrigerant

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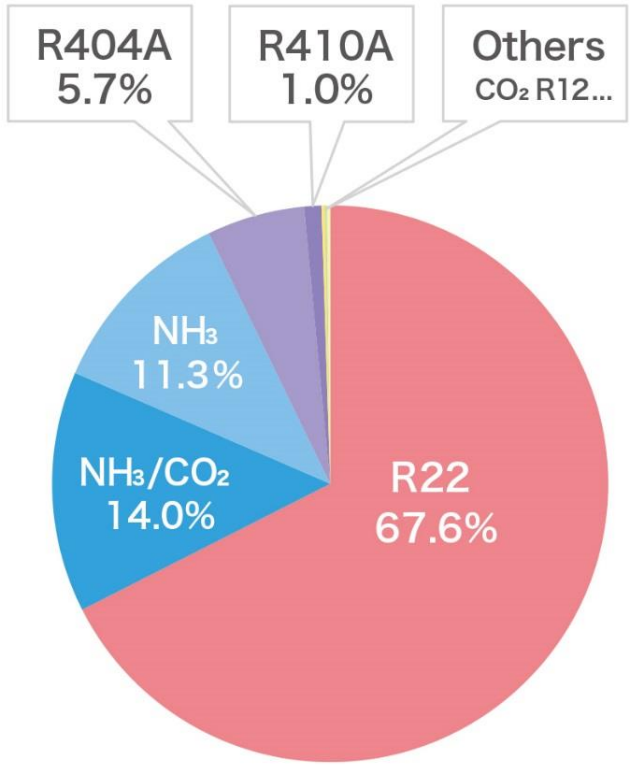
Japan Association of Refrigerated Warehouses



HCFC	R22	67.6 %
Natural refrigerant	NH_3/CO_2	14.0 %
Natural refrigerant	NH_3	11.3 %
HFC	R404A	5.7 %
HFC	R410A	1.0 %
CFC	R502	0.2 %
Natural refrigerant	CO_2	0.1 %
Natural refrigerant	Air	0.1 %
CFC	R12	0.1 %

※ Data : Japan Association of Refrigerated Warehouses 2016

Target of power reduction
Japan Association of Refrigerated Warehouse

References http://www.keidanren.or.jp/policy/2017/101.html

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Japan Association of Refrigerated Warehouses

	unit	1990 (base year)	2015	2016	Target 2020年	Target 2030年
Effective volume of working warehouse	[$\times 10^3$ m^3]	20,755	30,035	30,195	28,750	28,750
Power consumption	[$\times 10^8$ kWh/year]	14.9	18.4	18.5	17.5	16.5
Power consumption over warehouse volume	[kWh/(m^3 · year)]	71.8	61.3	61.3	60.9	57.4

15% reduction

20% reduction

Cold Storage in Hiroshima

- **Replacement of R22 unit to CO2 Super Green unit**
- End-user Tanaka Warehouse and Transportation Cold storage in Hiroshima
- Specification Gas Cooler Separate Type
  F-2(68kW) x 1unit -25℃
  C-2(88kW) x 1unit +10℃
- Volume Type F 8,083 m^3 Type C2,785 m^3
- Start Operation March 2018

Power Consumption: R22 vs. CO_2

Cold storage in Hiroshima
(Tanaka warehouse and Transportation Co., Ltd.)

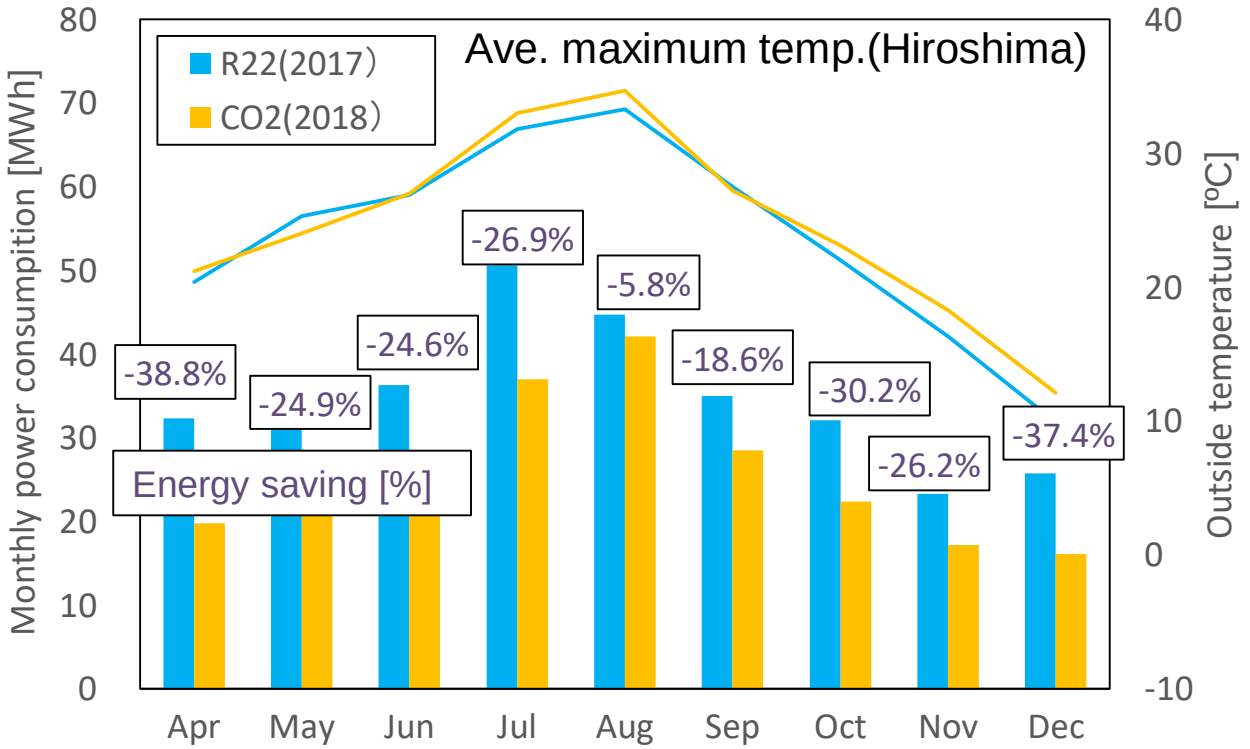


Fig. Comparison of power consumption

Annual Power consumption over warehouse volume (prediction) : 30.0 kWh / (m^3 · year)

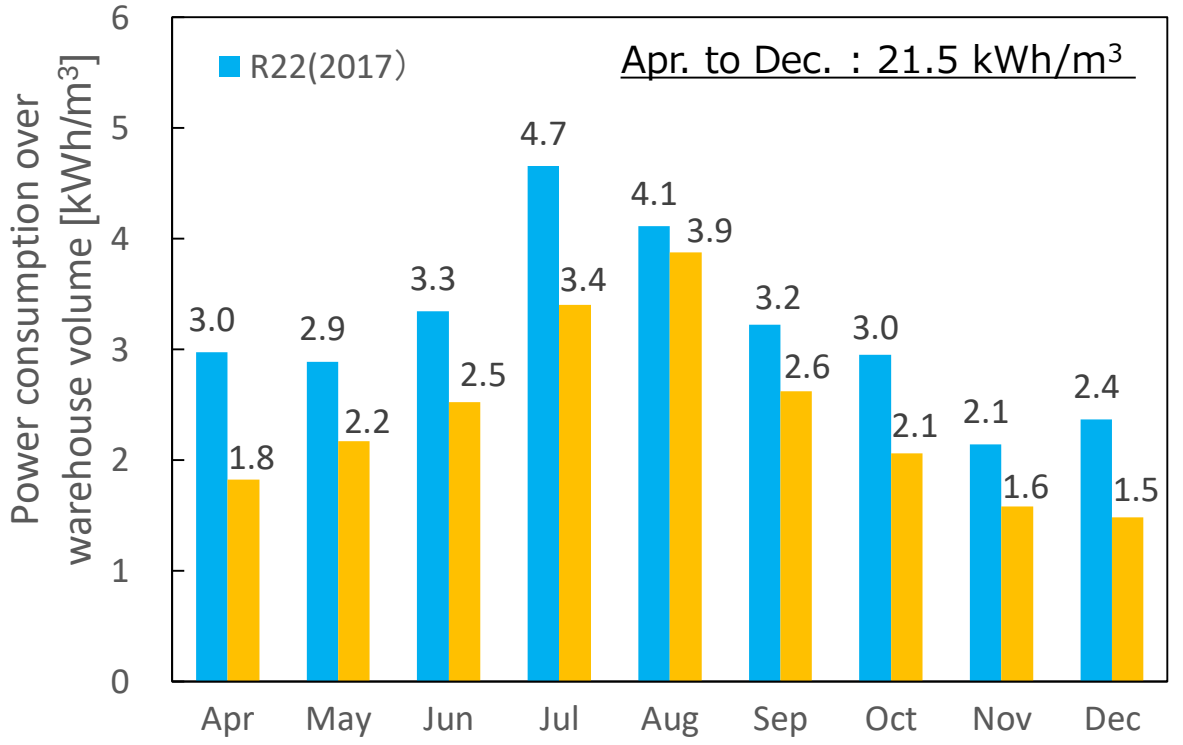
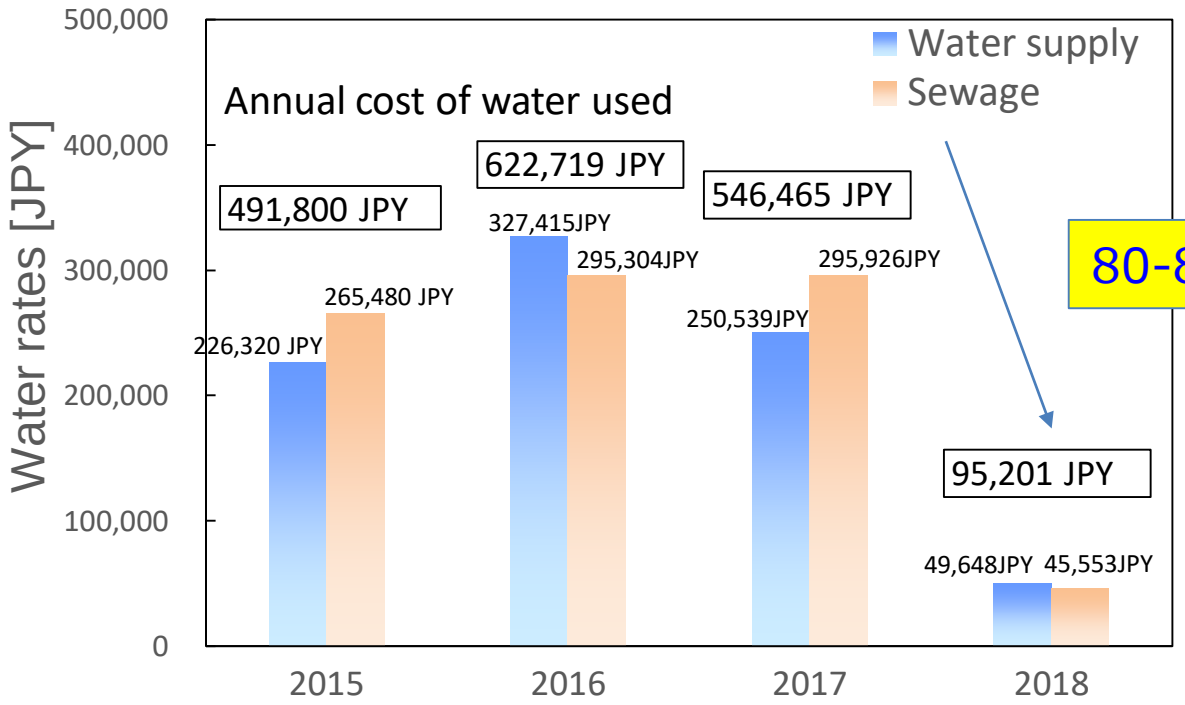


Fig. Power consumption over warehouse volume

Water Cost: Water Cooling vs. Air Cooling



80-85% water cost down

The cost of water was drastically decreased by introducing the CO_2 unit due to the air-cooling system without cooling tower

R22 unit

Heavy water was used for cooling tower

CO_2 unit (air cooling system)

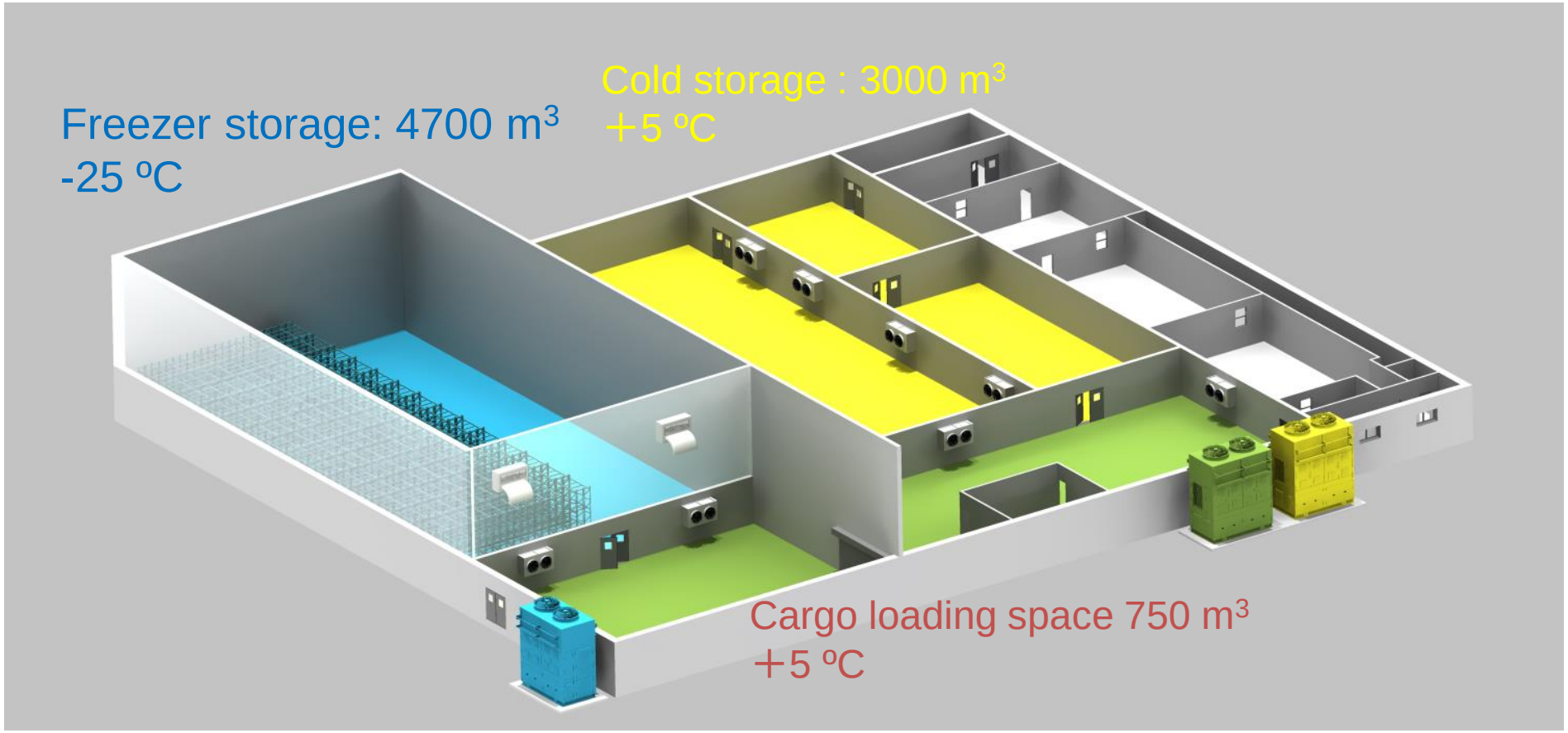
Few water was used for the water spray into the gas cooler during the summer season over 35 ºC

Cold Storage in Fukuoka

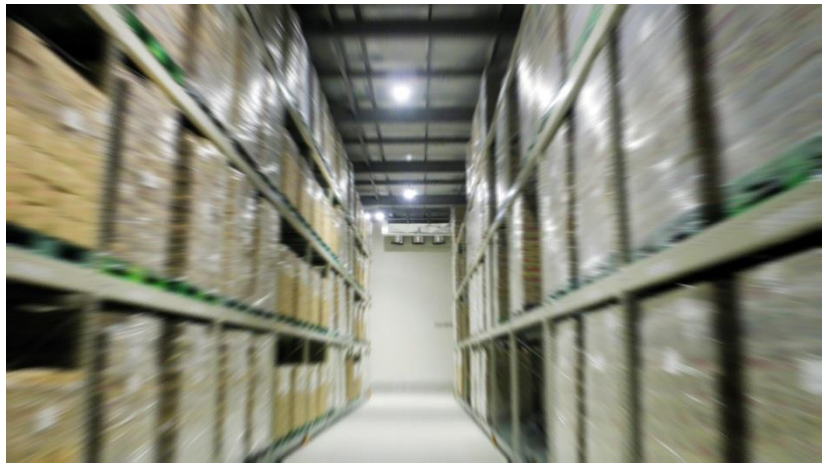
- End-user — Yoshio Ice Manufacturing and Refrigeration
  Cold storage in Fukuoka
- Specification — One box Type
  F-2(68kW) x 1unit -25℃
  C-2(88kW) x 2unit +5℃
- Volume — Type F 4,700m³
  Type C 3,000m³
  Cargo Loading 750m³
- Start Operation — March 2018

Cold Storage in Fukuoka

YOSHIO LOGISTICS CENTER
YOSHIO ICEMANUFACTURING&REFRIGERATION Co.,Ltd



Cold Storage in Fukuoka



Cold Storage in Fukuoka

Freezer storage -25 ºC (4700m^3)
Cold storage +5 ºC (3000 m^3)
Cargo loading space +5 ºC (750m^3)

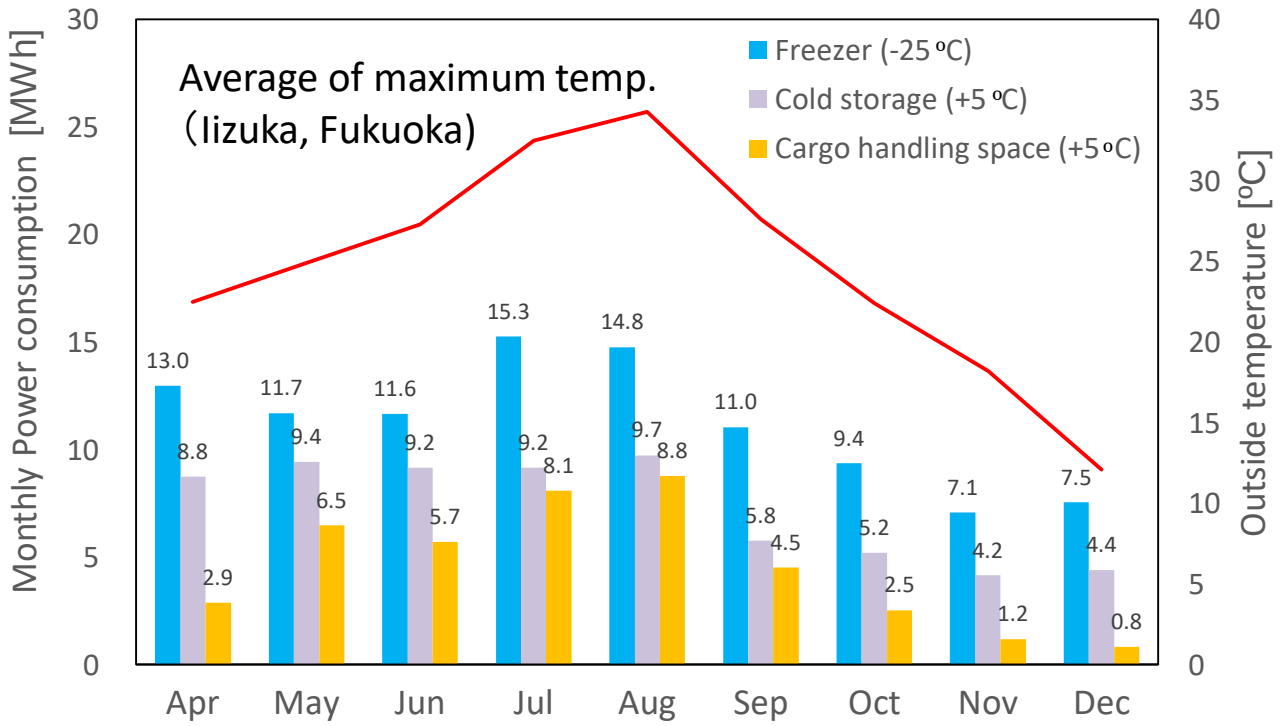


Fig. Power consumption in newly established storage by CO_2 refrigerator

Annual Power consumption over warehouse volume (prediction) : 35.0 kWh / (m^3 · year)

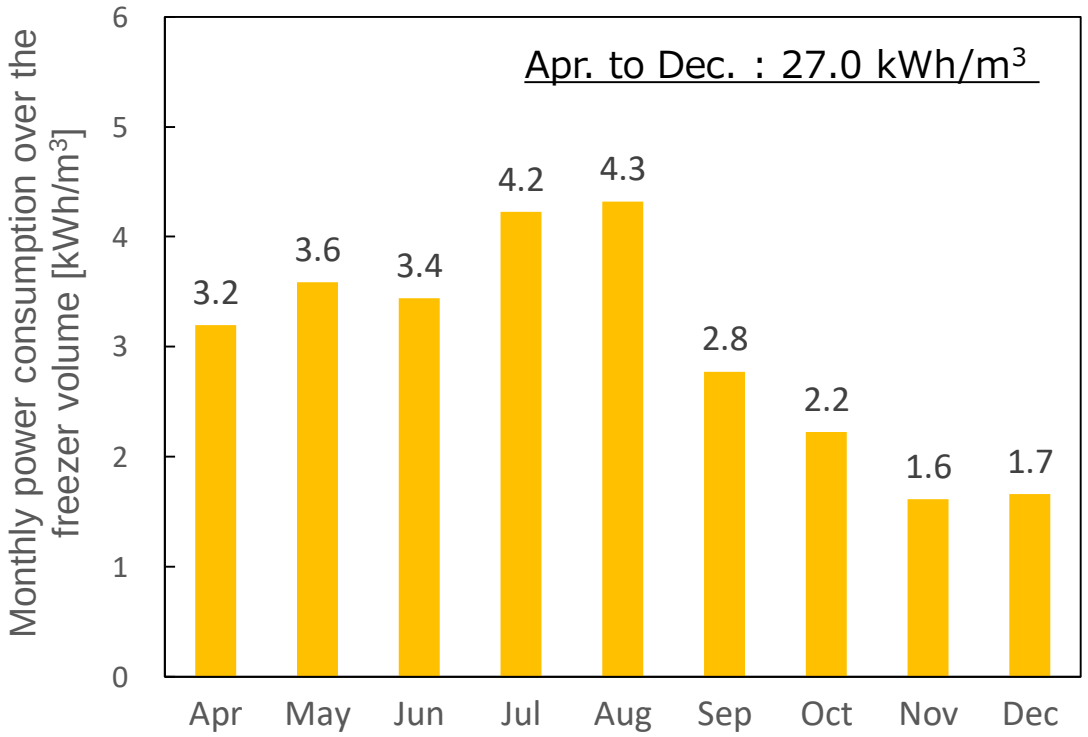


Fig. Monthly power consumption over the Freezer volume

Logistic Center in Fukuoka

- End-user Kawai Ice and Cold Storage
  Logistic center in Fukuoka
- Specification One box Type
  F-2(68kW) x 8unit -25℃ and -40℃
  C-2(88kW) x 2unit +5℃
- Volume Type F: 55,000m³ -25℃
  Super Freezer: 1125m³ -40℃
  Type C 2,900m³ +5℃
- Start Operation May 2018

Logistic Center in Fukuoka

1F 27,500 m^3

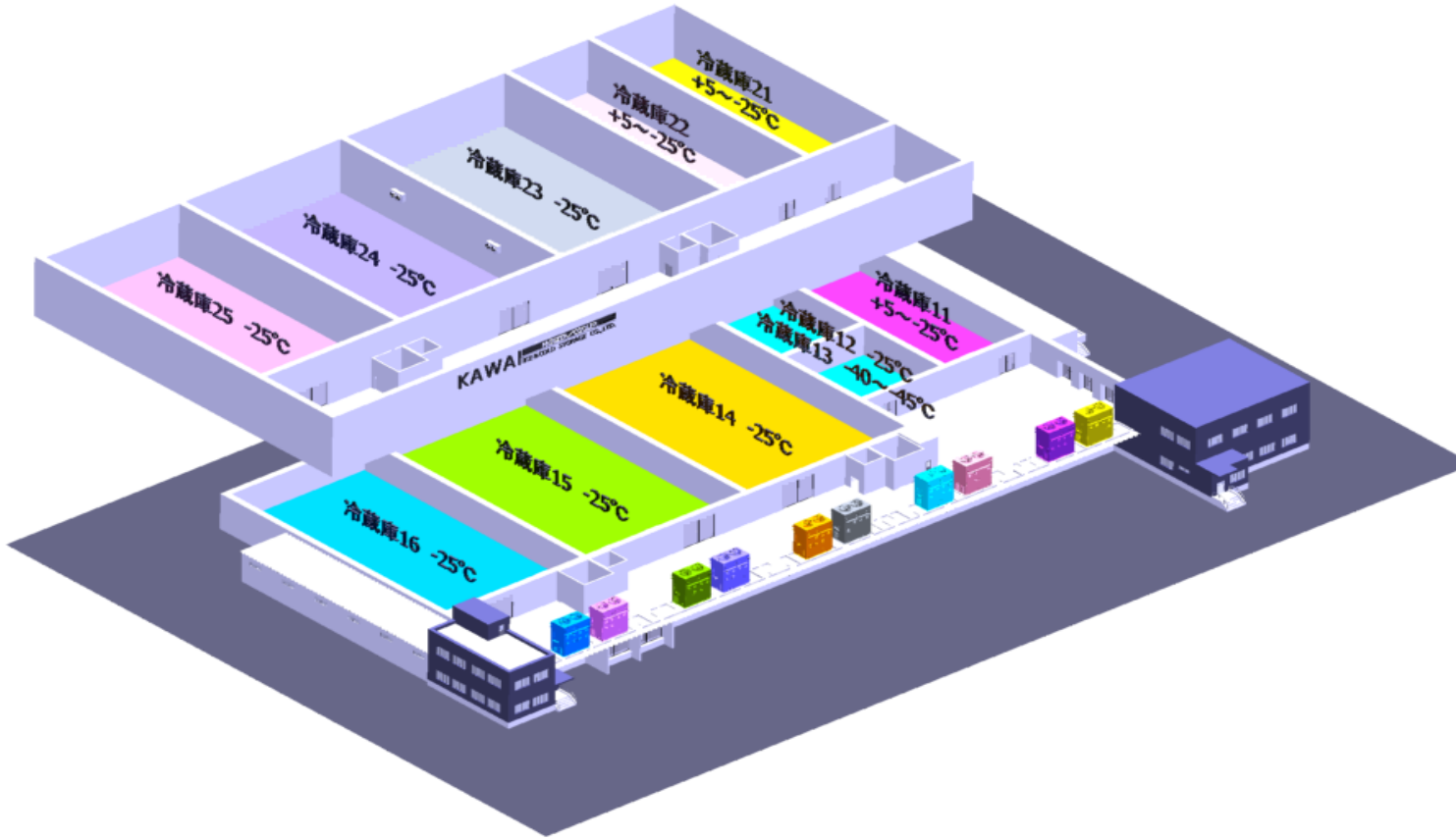
Freezer : -25 ºC, 4 rooms

Freezer or cold storage: +5 …-25 ºC, 1 room

Super freezer: - 40 ºC, 1 room

2F 29,000 m^3

Freezer: -25 ºC, 4 rooms



Logistic Center in Fukuoka

Logistic Center in Fukuoka

F-2: 7 units* (-25 °C, 43,114m³)　*Actual working units
C-2: 2 units (+5°C、19713m³)

Annual Power consumption over warehouse volume (prediction) : 34.0 kWh / (m³ · year)

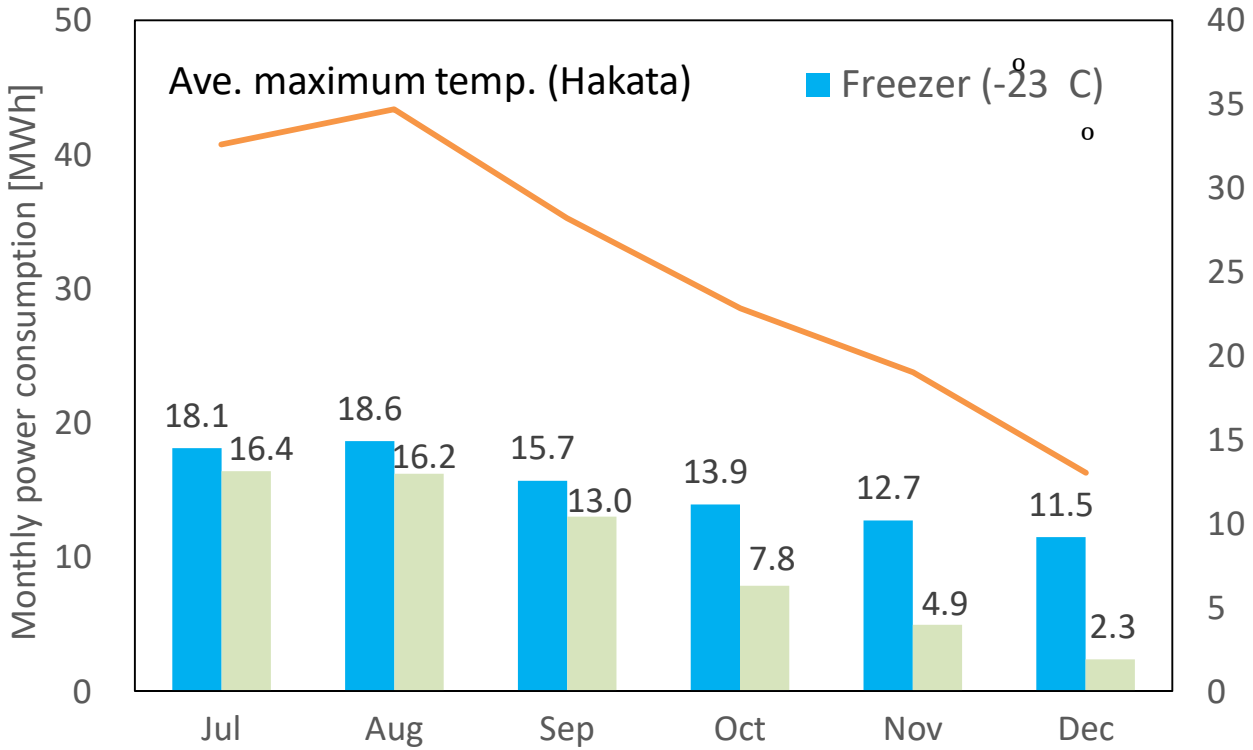


Fig. Monthly power consumption

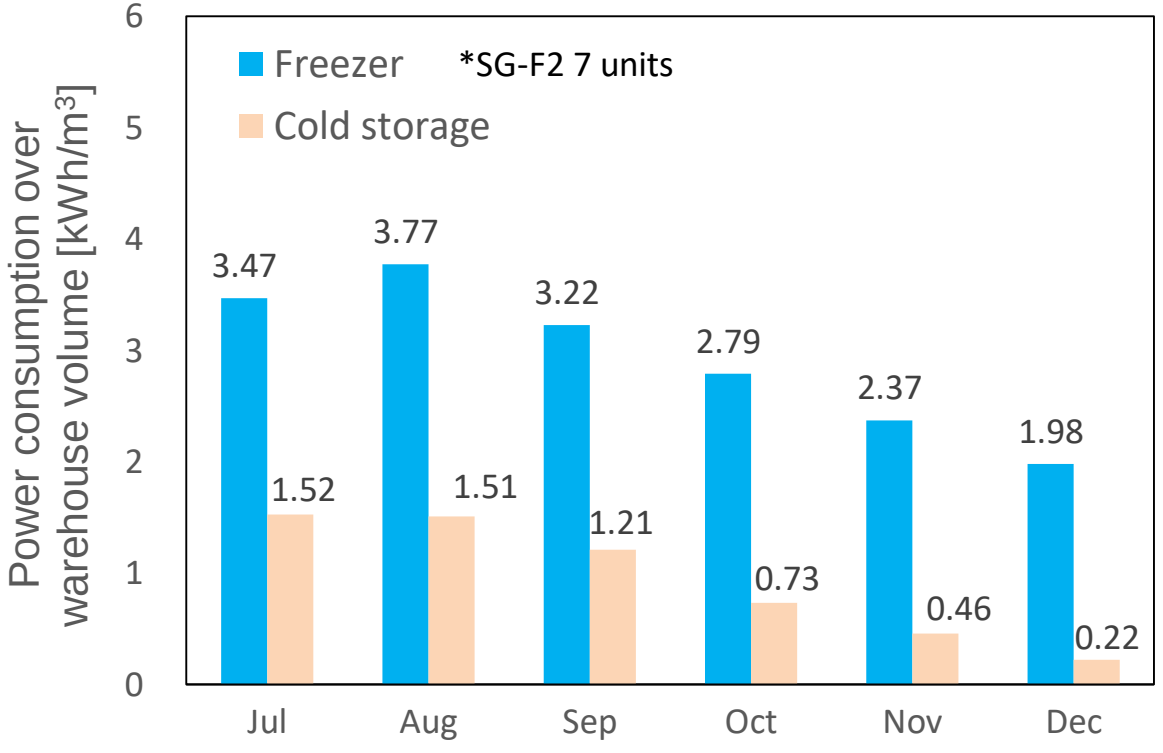
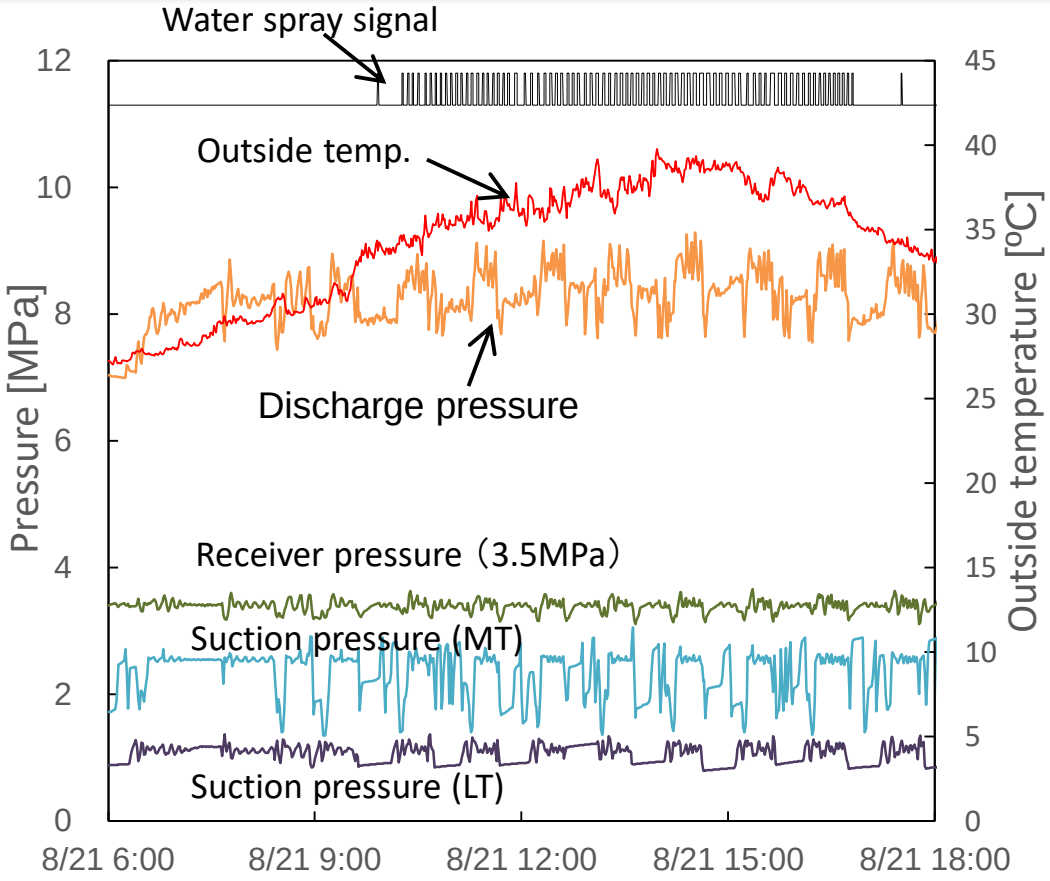
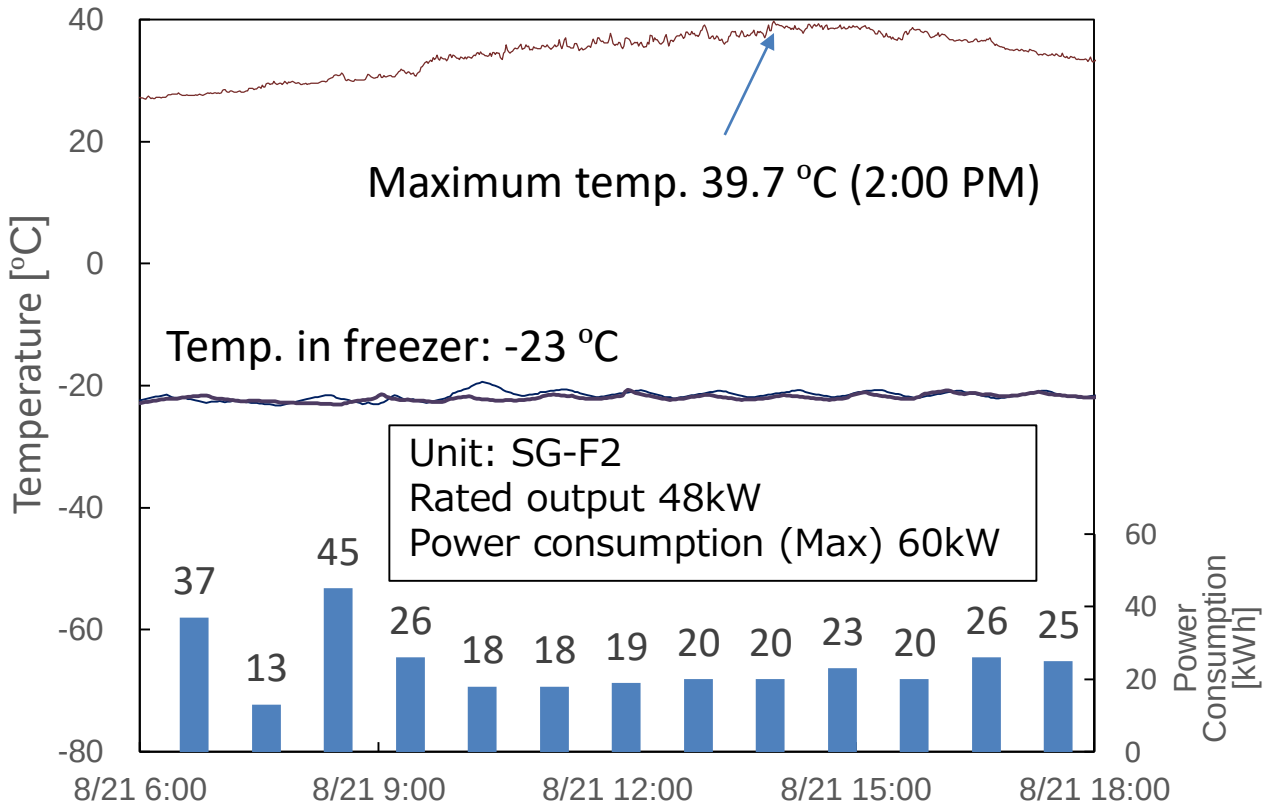


Fig. Power consumption over warehouse volume

Summer Data 21st August 2018, 39.7°C





Freezing room temperature shows constant of -23 °C, even ambient temperature was almost 40 °C

Summary

Question 1: Can CO_2 unit survive hot summer in west or south of Japan?
Answer2: Yes. We didn't have any problem under record hot summer 2018.
When ambient temperature was almost 40℃, the unit kept constant cooling.

Question 2: How much energy saving can be achieved compared with R22 unit?
Answer2: We achieved 6-39% energy saving monthly in Hiroshima.
Storage insulation was not renewed in this project.
Energy saving was simply achieved by the replacement of refrigeration unit.

Two Fukuoka projects also showed high energy saving which were almost 40% down of JARW target in 2030.

Question 3: Why NNS CO2 unit can perform good COP even in summer?
Answer3: We focus on control logic to fit to Japanese climate.
All compressors are controlled by frequency converters
Large capacity of liquid receiver which can absorb ambient temperature fluctuation

Thank you !