

High Ambient Energy Efficient CO2 Refrigeration Unit for Supermarket and CVS.



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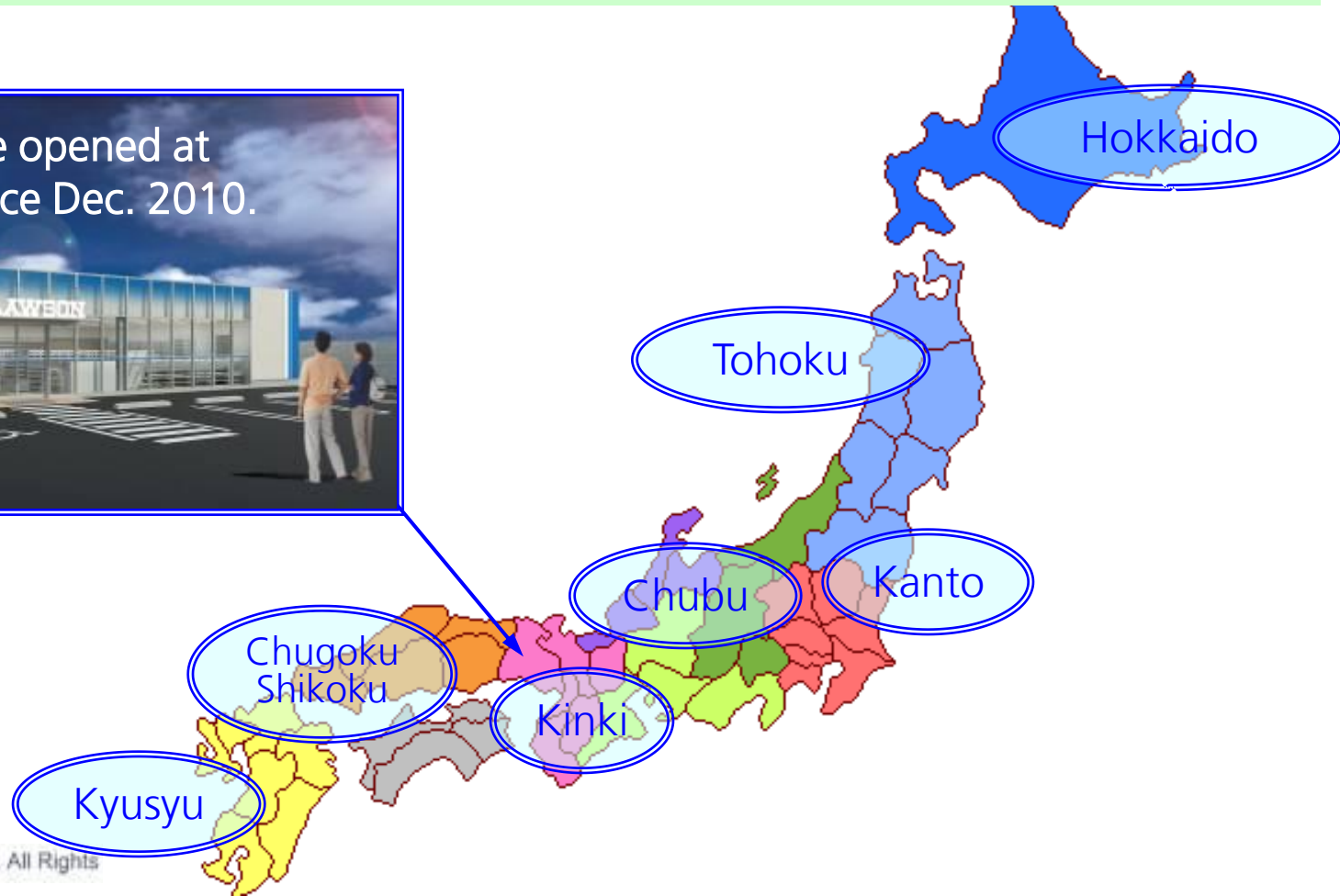
Agenda

1. Introduction of LAWSON Activity (Japanese CVS chain)
2. Refrigerant Transition in Japan for Commercial refrigerator (SANYO's view)
3. Efficiency Analysis (CO₂ and R404A)
 - Labo test at Rated Test Condition
 - Measured data from the field (Winter ~ Summer)
 - Theoretically calculated efficiency
4. Consideration and Summary

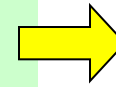
Total **50** demonstration stores covering all 7 branches will open before March 2012.

- Verify the energy consumption difference by location and climate.
- Spread out 500 stores by 2016.

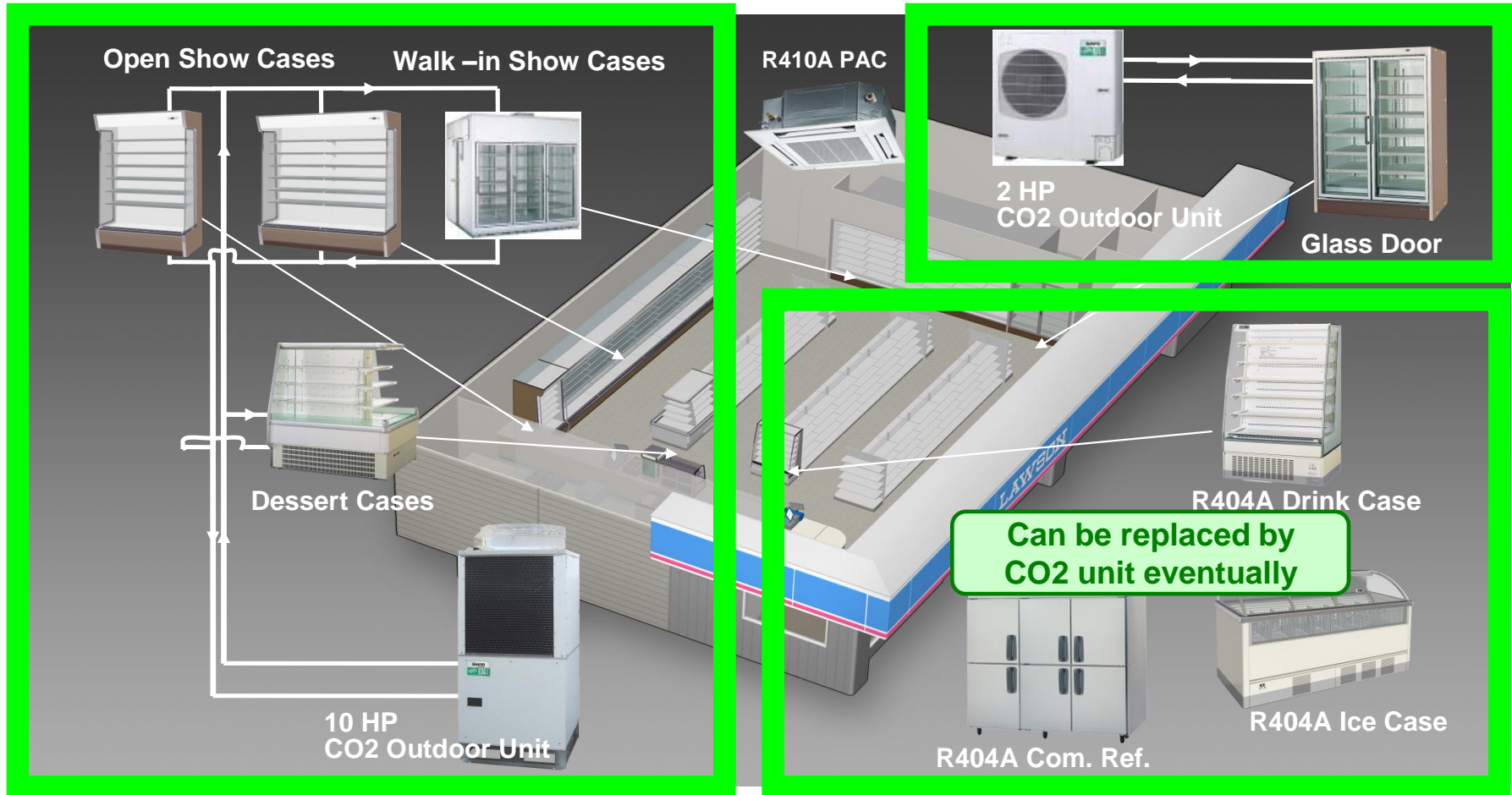
1st Model Store opened at Kyo-tanabe since Dec. 2010.



Outdoor units for Refrigerators and Freezers were replaced by SANYO CO2 Units (10HP and 2HP)



The Total Energy Save: **32%**

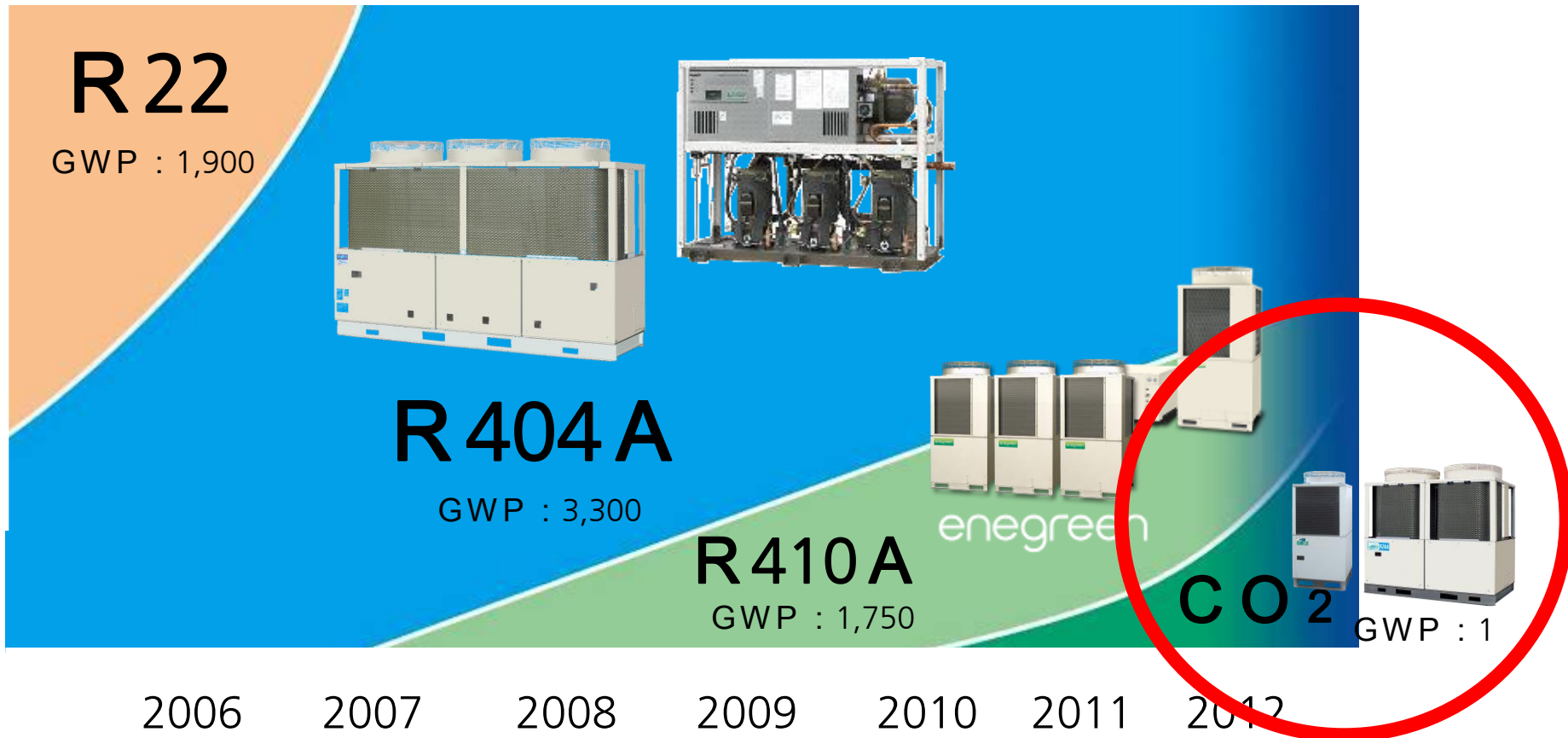


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Refrigerant Transition in Japan (SANYO's view)

Considering the Environment Impact, CO₂ is the best refrigerant for Commercial Refrigeration System.



Transition of COP at Rated Condition (AT 32C)

At Rated Condition Comparison, there is no big COP improvement.

◆ Freezer (- 40C Eva. Temp.) AT: 32C

Year	2000	2008	2010	2011
Model Code	OCU-S2002DF	OCU-NS2000MVF	OCU-GS2000MVF	Sales started in 2010
Motor Type	Single Speed	Single Speed	INVERTER	INVERTER
Refrigerant	R22	R404A	R404A	R744
Cooling Capacity (kW)	11.0	12.4	12.4	14.3
Input (kW)	12.7	14.9	14.9	14.2
COP	0.87	0.83	0.83	1.01

◆ Refrigerator (- 10C Eva. Temp.) AT: 32C

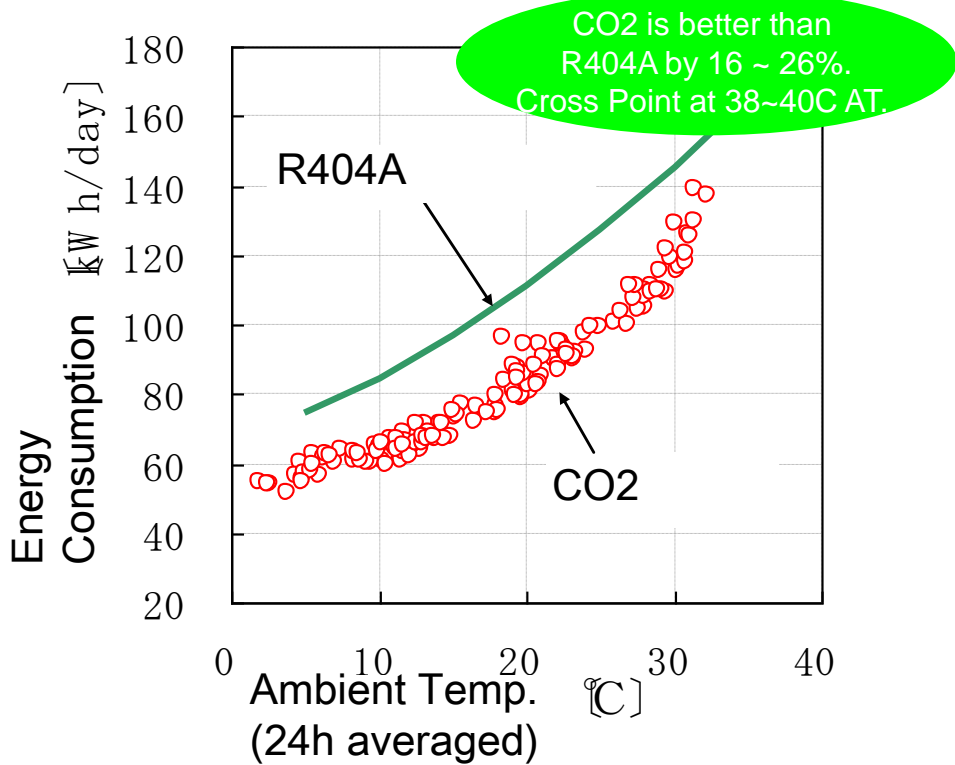
Year	2000	2008	2010	2011
Model Code	OCU-S2002DF	OCU-NS2000MVF	OCU-GS2000MVF	To be determined
Motor Type	Single Speed	Single Speed	INVERTER	INVERTER
Refrigerant	R22	R404A	R404A	R744
Cooling Capacity (kW)	37.3	42.6	42.6	32.5
Input (kW)	17.3	21.4	21.3	16.3
COP	2.16	1.99	2.00	1.99

Measured Energy Consumption Comparison

Though we don't see big difference at rated condition comparison, CO2 is confirmed to outperform R404A system at Measured Energy Consumption Comparison. → Why ??

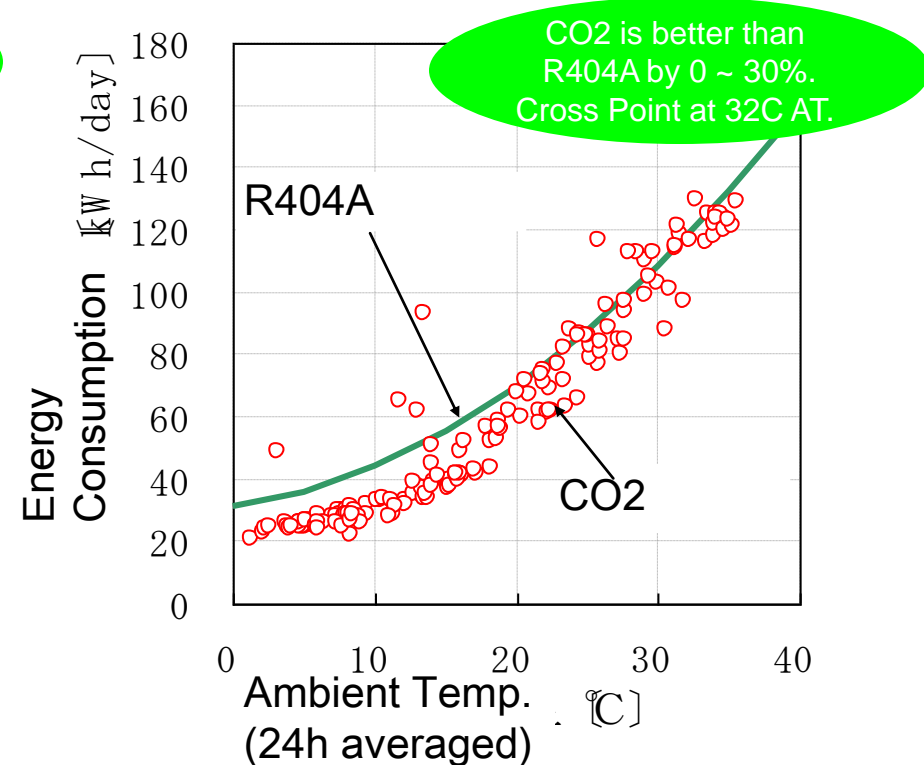
◆ Freezer Application

Room temp: -25C



◆ Refrigerator Application

Room temp: +5C



Why CO2 unit works better than expected?

Though we don't see big difference at rated condition comparison, CO2 is confirmed to outperform R404A system at Measured Energy Consumption Comparison. → Why ??

CO2 refrigerant is said to be less efficient. But the actual data is different. → Why ??

1. CO2 performs relatively better at cold climate.

AT 32C comparison may not be fair.

2. Components are different (HX, DC INV motor, etc..).

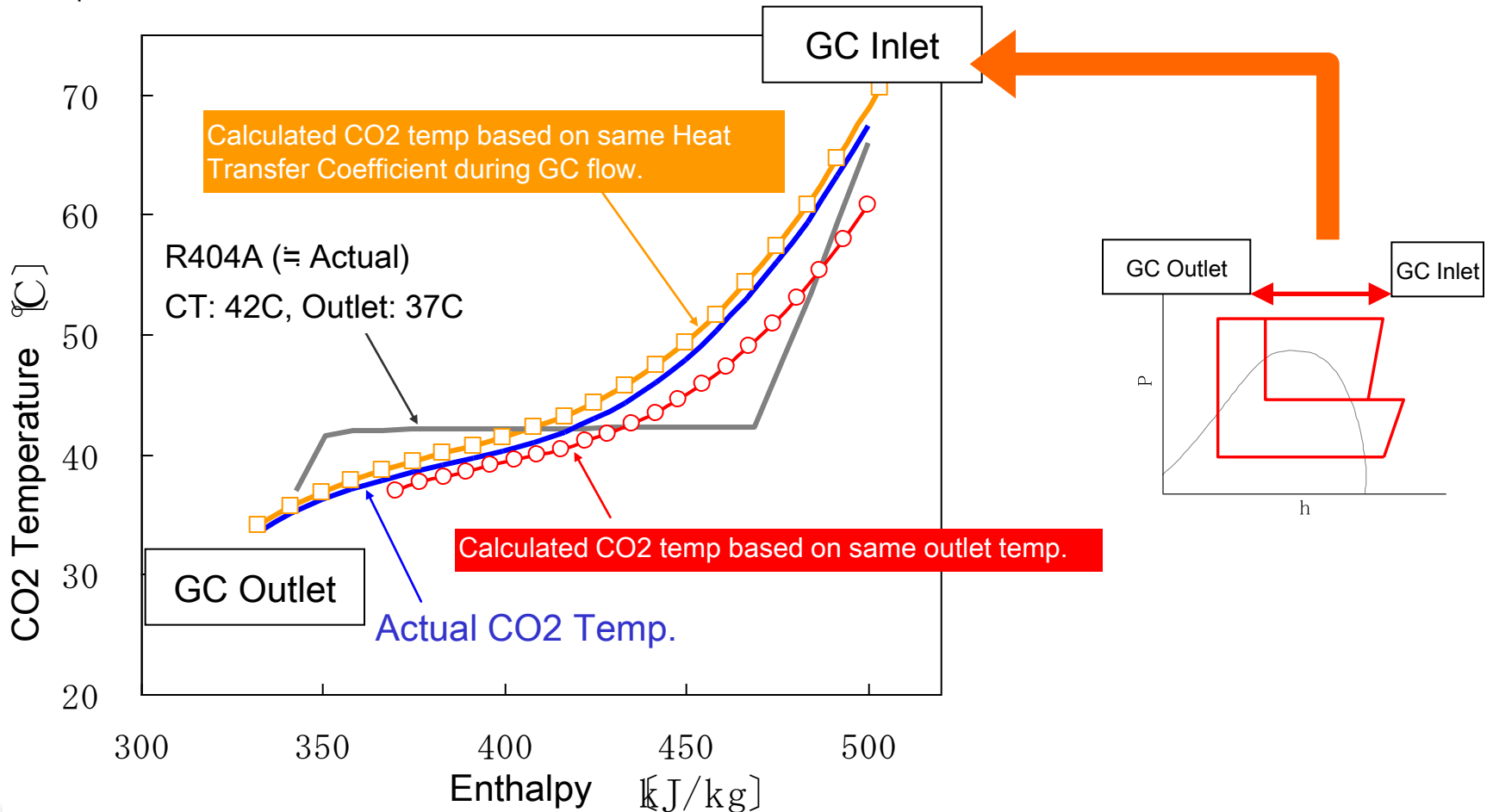
3. Refrigeration Cycle is different.

Good cycle for R404A is not best for CO2.

Definition of Theoretical Efficiency

Calculated CO2 temperature trend based on same Heat Transfer Coefficient matches the actual temperature trend.

- ◆ Temperature Trend at "Gas Cooler Inlet ~ Outlet"



Definition of Cycle

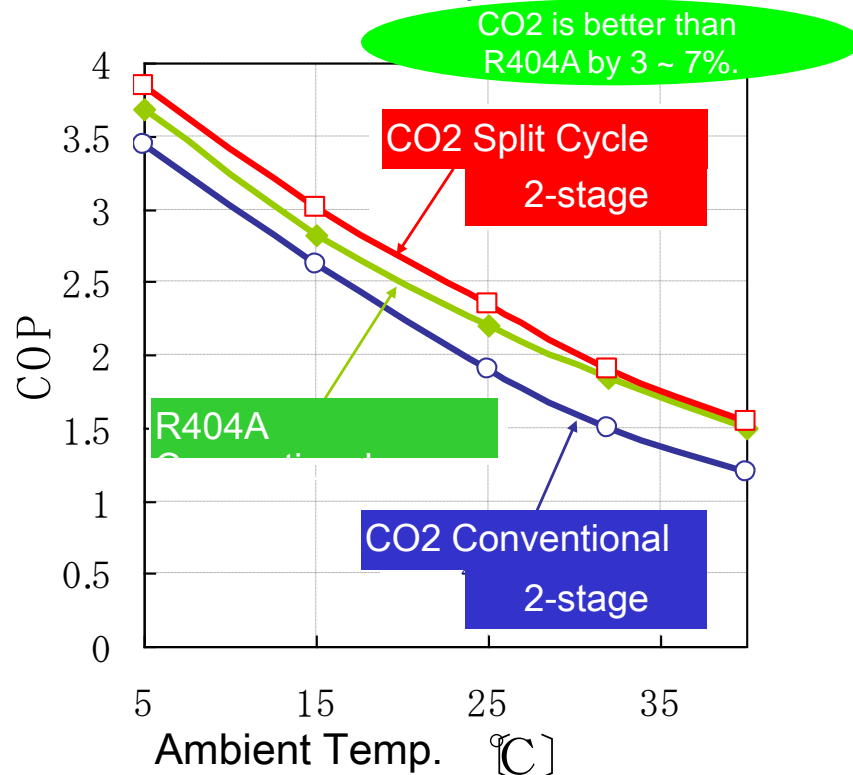
◆ Refrigeration Cycle Compared in this study

	CO2 Split Cycle	CO2 Conventional Cycle	R404A Conventional Cycle
Compression	Two-stage (utilize Intercooler)		One-stage
SLHX	Yes		No
Split (Economizer)	Yes	No	
PH Diagram			

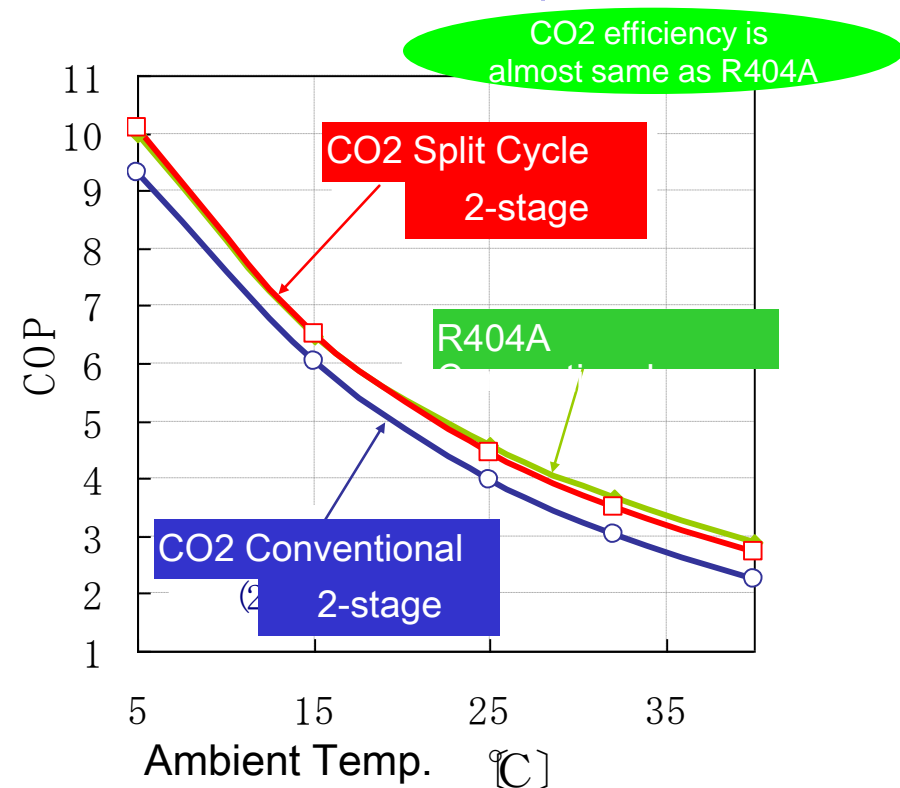
Theoretically Calculated Efficiency Comparison

Using the same Heat Transfer Coefficient, the system COP of CO2 split cycle can outperform R404A. → same trend as measured data.

◆ Freezer Application - 40C Eva. Temp.



◆ Refrigerator Application - 10C Eva. Temp.



Consideration and Summary

1. The superiority of CO₂ cycle efficiency is difficult to be confirmed at rated condition (AT32) comparison. But, actually CO₂ outperforms R404A in the market.
2. The measured data comparison showed that CO₂ split cycle is better than R404A original system by **16-26% at LT use and 0-30% at MT use**. Cross point exists at high ambient temp. more than 32C.
3. Theoretically calculated efficiency based on the same Heat Transfer Coefficient showed that CO₂ split cycle is better than R404A original system by **3-7% at LT use and almost same at MT use**.
4. The remaining GAP of efficiency comparison (measured v.s. calculated) might be resulted from the components improvement.
→ It is fair. New technology shall be used for new refrigerant. It is natural to pursue the best performance with available technology.

→ Next steps?