



# Case Study

Transcritical CO<sub>2</sub> for cold storage facilities

Application of  
CO<sub>2</sub> compared to R 404A  
under different climatic conditions.

# Cold Storage for fruit and fresh produce

## Modernization

Storage area of 6,450 m<sup>2</sup>

- Fruits (2,650 m<sup>2</sup>)
- Fresh produce (3,800 m<sup>2</sup>)



# Cold Storage for fruit and fresh produce

## Technology: Before Modernization

Storage area of 5,200 m<sup>2</sup>

Technical equipment:  
7 rack units / 2 single machines

Refrigerant:

- R 422D (GWP = 2,620)
- R 404A (GWP = 3,922)
- R 407F (GWP = 1,825)



# Requirements

Modernizing and saving energy under following conditions

1. Conversion during operation
2. Sustainable plant
3. Energy saving of approx. 10 %.



Modernizing and saving energy under following conditions

## 1. Conversion during operation

- First step conversion of the fresh warehouse
- Second step conversion of the fruit warehouse

Modernizing and saving energy under following conditions

## 2. Sustainable plant

- Natural refrigerant CO<sub>2</sub> / R 744
- GWP 1
- Long lasting
- Constant costs per kg refrigerant

Price comparison (Germany)

- R 744 = 1.510 Yen / kg
- R 404A = 10.850 Yen / kg

600 kg refrigerant in use

→ 906.000 YEN for CO<sub>2</sub>

→ 6.510.000 YEN for R 404A



Modernizing and saving energy under following conditions

## 3. Energy saving of approx. 10 %.

1 °C increase in evaporation temperature → 3 % energy savings

Achieve comparable cooling capacities with higher evaporation temperatures

- From  $t_o$  -12 °C to  $t_o$  -4 °C fresh produce
- From  $t_o$  -15 °C to  $t_o$  -6 °C fruit storage
- by machine modification
  
- Additional increase from  $t_o$  -4 °C to  $t_o$  0 °C fresh produce
- Additional increase from  $t_o$  -6 °C to  $t_o$  -2 °C fruit storage
- by special TEKO technology

Particular challenge:

- drive the evaporator through an **overheating** of close to **0 Kelvin**
- keep the **evaporation temperature** as **high** as possible



# Cold Storage for fruit and fresh produce

## Technology: After Modernization

Fresh produce unit: MT 156 kW ( $t_o$  -2 °C incl. TEKO technology / without it would be  $t_o$  - 6°C)

LT cascade: LT 25 kW ( $t_o$  -33 °C)

Gas cooler: 320 kW ( $t_{GC}$  38 °C)

Fruit unit: MT 135 kW ( $t_o$  0 °C incl. TEKO technology / without it would be  $t_o$  -4 °C)

Gas cooler: 232 kW ( $t_{GC}$  38 °C)

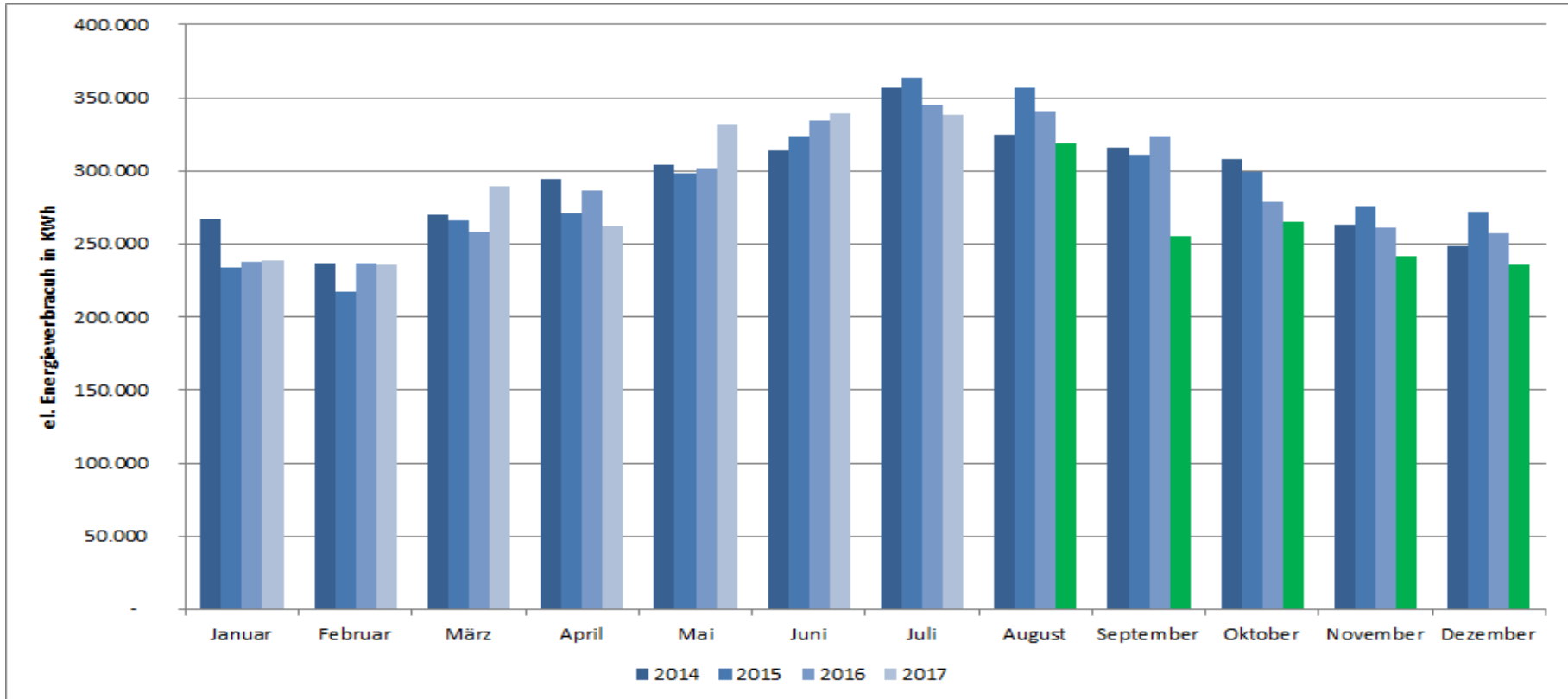
Refrigerant: R 744



New

# Energy consumption (kWh)

New technology since August 2017



# Energy consumption (Yen)

kWh \* 0,17 EUR (costs of electricity in Germany) \* 134,52 Yen (conversion of currencies)

Yen	2014	2015	2016	2017	relative savings compared to average 2014-2016
Januar	6.115.925	5.350.382	5.444.349	5.462.300	
Februar	5.425.894	4.970.881	5.410.709	5.385.440	
März	6.168.431	6.081.942	5.902.883	6.628.108	
April	6.743.823	6.197.725	6.560.967	5.987.450	
Mai	6.952.222	6.828.596	6.882.451	7.585.197	
Juni	7.168.169	7.399.368	7.650.029	7.752.593	
Juli	8.163.218	8.320.393	7.898.928	7.734.619	
August	7.428.937	8.157.730	7.772.420	7.294.905	94 %
September	7.228.816	7.105.258	7.402.478	5.848.113	81 %
Oktober	7.052.729	6.840.830	6.371.891	6.060.835	90 %
November	6.027.333	6.312.525	5.973.089	5.528.802	91 %
Dezember	5.684.032	6.215.883	5.895.108	5.394.198	91 %
<b>Summe</b>	<b>80.159.528</b>	<b>79.781.513</b>	<b>79.165.301</b>	<b>76.662.561</b>	

*On average*

**10 %**

*Money savings  
compared to  
2014-2016*



*With an  
enlargement of  
the area by  
**1,250 m<sup>2</sup>***

# Expected payback time

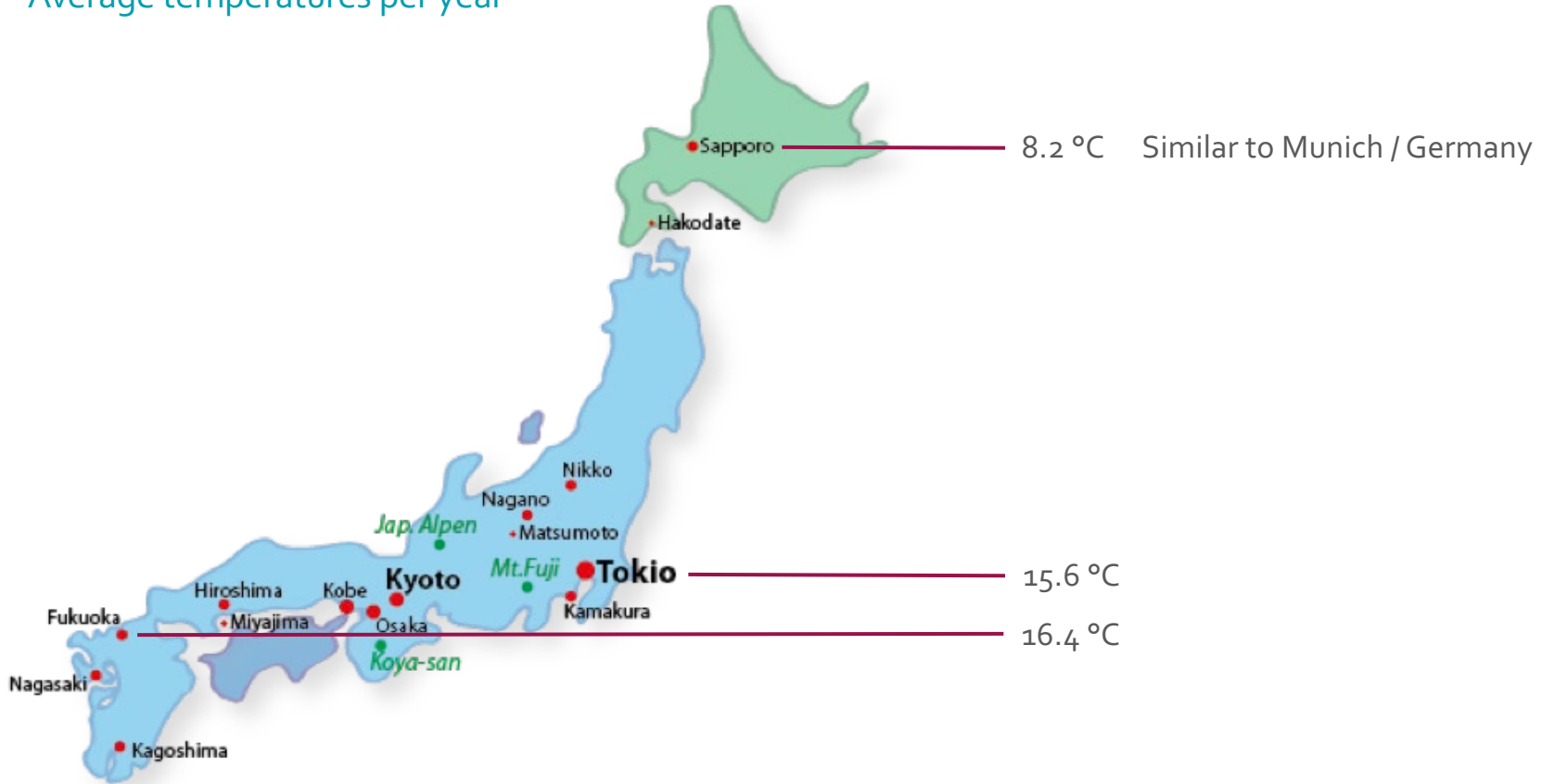
## Saving per year

The operator assumes a **payback period** of approximately **4 to 5 years** for the entire conversion incl. refrigeration plant, heat exchangers, pipe network, lighting, insulation, additional storage areas.

**Saving per year approx. 11.000.000 YEN.**

# Temperature conditions in Japan

## Average temperatures per year



# Energy values – CO<sub>2</sub> to R 404A (only Rack unit)

## Consideration of ambient temperatures per hour and year

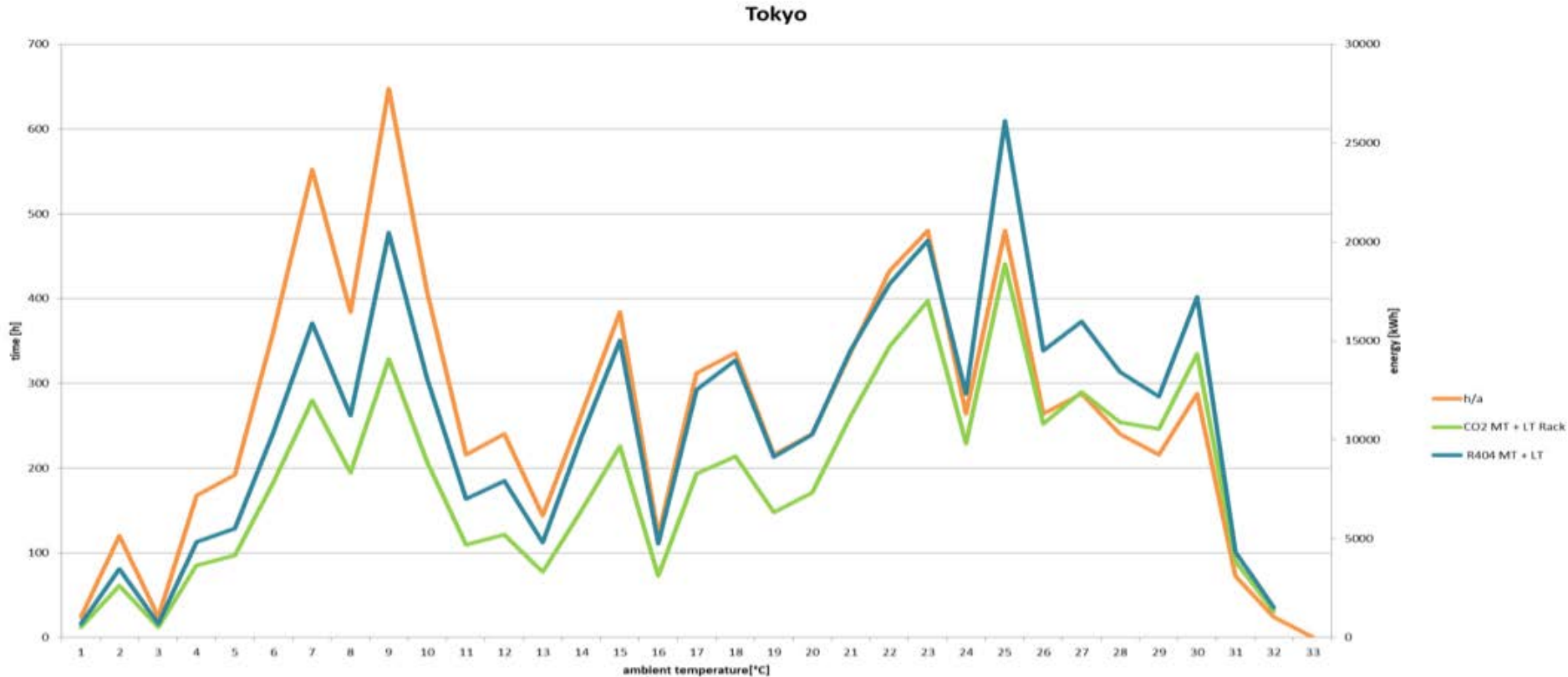
Installation	Unit	Consumption [kWh/a]	Consumption YEN	Saving in %	Saving in YEN
Munich	CO <sub>2</sub>	347.863	7.955.070	38,73	3.081.220
	R404A	482.600	11.036.290		
Sapporo	CO <sub>2</sub>	352.913	8.070.556	38,02	3.068.368
	R404A	487.088	11.138.923		
Tokyo	CO <sub>2</sub>	416.398	9.522.356	33,75	3.214.154
	R404A	556.948	12.736.510		

Invest of CO<sub>2</sub> rack is **20 – 30 %** higher compared to R 404A. Payback period around **2,5** years.

Conditions		CO <sub>2</sub>	R 404A
MT 1	Q <sub>o</sub> [kW]	156	156
	t <sub>o</sub> [°C]	-2	-6
	t <sub>c</sub> [°C]	ta + 2K	20°C min < ta + 13K > 45° max.
	duration [h/d]	16	16
	T <sub>oh</sub> [K]	0	12
	LT	Q <sub>o</sub> [kW]	25
	t <sub>o</sub> [°C]	-33	-33
	t <sub>c</sub> [°C]		ta + 20K > 45° max.
	duration [h/d]	18	18
	T <sub>oh</sub> [K]		18
MT 2	Q <sub>o</sub> [kW]	135	135
	t <sub>o</sub> [°C]	0	-4
	t <sub>c</sub> [°C]	ta + 2K	20°C min < ta + 13K > 45° max.
	duration [h/d]	16	16
	T <sub>oh</sub> [K]	0	12

# Energy values – CO<sub>2</sub> to R<sub>404A</sub>

Consideration of ambient temperatures per hour and year

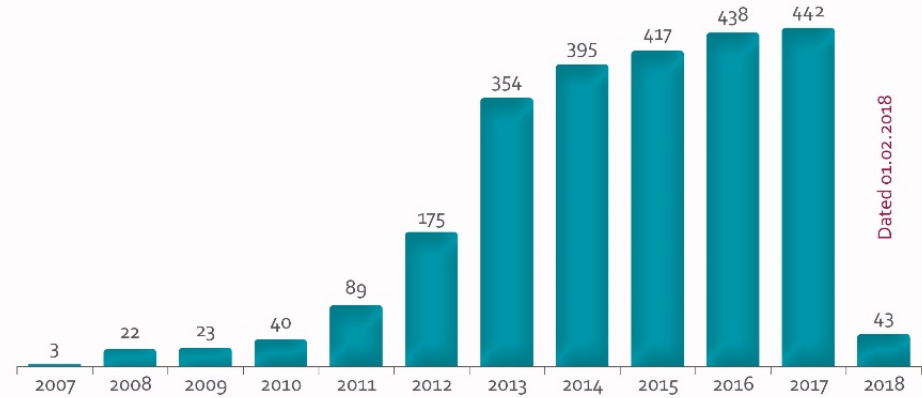


# CO<sub>2</sub>-Engagement

More than 2,400 CO<sub>2</sub> units in the field

## Applications

- Discounter
- Supermarkets / full range
- Cash & carry markets
- Logistics storages



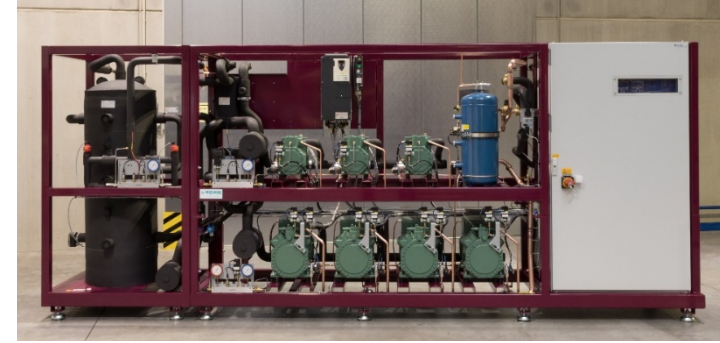
Series  
production  
at TEKO





# TEKO contact details

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