



NTNU – Trondheim
Norwegian University of
Science and Technology

KIFEE 2012 - 6th KIFEE Symposium on Environment, Energy and Materials

KIFEE-Symposium

9 - 12 September 2012

Organized by NTNU in Trondheim, Norway

NATURAL REFRIGERANTS IN DIFFERENT INDUSTRIAL APPLICATIONS

LINE-UP NATURAL 5

FIELD CASES

Mayekawa Mfg.Co,Ltd
Kunuaki Kawamura

Commitment on Natural Refrigerants



-  Semi-Hermetic Screw Compressor Unit
-  Commercial / Industrial Eco-Cute System
-  Adsorption Chiller
-  Commercial / Industrial
Air-Conditioning / Water-Supply Heat Pump
-  Dehumidifying Air Refrigerant System [Air Ref]

"Natural Five" Refrigerants and Product Solutions

Refrigerant (Natural Five)	NH ₃ R-717	CO ₂ R-744	HC Hydrocarbon	H ₂ O R-718	Air R-728
90°C		Utility hot water			
60°C	Utility hot water Heating		Utility hot water Heating HVAC	Heat recovery	
10°C	Chilled water Ice making	Chilled water Ice making		Chiller	
-15°C	Cold storage, Freezer, Fish boat				
-25°C	Specific Refrigeration needs				
-40°C	Freezer, Freeze-dry, Super Low temp storage				
-50°C					
-60°C			Cryogenics		Cryogenics
-100°C					
Notes	•Conventional system •National Projects	•Eco-Cute	•Nat'l Proj. •Butane + Propane	•Nat'l Proj. •Adsorption •Heat recovery	•Nat'l Proj. •Air-cycle

FIELD CASES

NH3

- High Efficiency: Compressors and IPM Motors
- Low Charge:
 - * Secondary Refrigerant System(CO2)
 - * Direct Expansion System
- Less Leakage: Hermetic Motors

Ammonia

NH3 compression + CO2 secondary brine

MYCOM

Semi-hermetic Refrigeration Package

2007 Ministry of the Environment
[Enterprise of Technical Development Against Global Warming]



MAYEKAWA
MAYEKAWA Europe nv/sa

DOC.2012-361

Installation in Japan

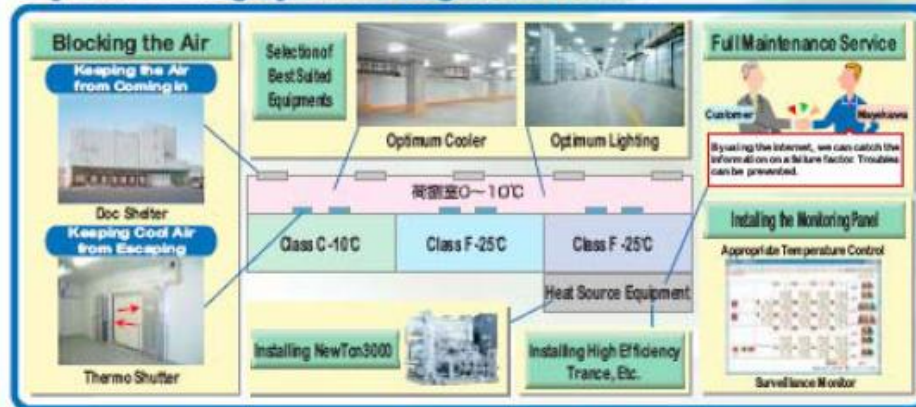


Distribution center



30% Reduction of CO2 Emission

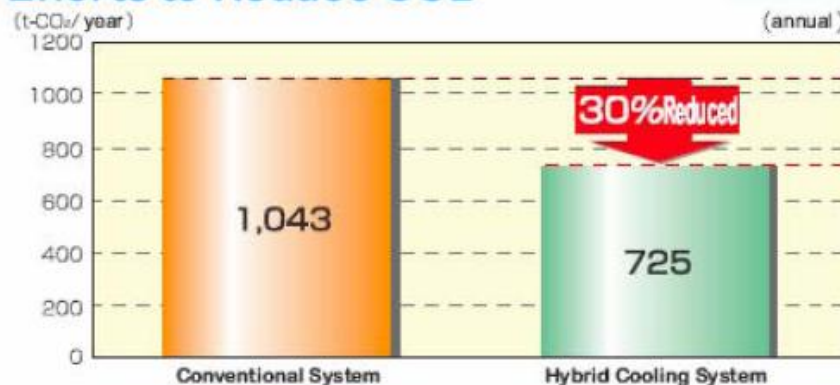
Hybrid Cooling System Using NewTon3000



Target : Industrial Refrigerated Warehouses (for Class F)

- **Improved Safety** : By developing [Semi-hermetic compressor], Mayekawa improved the problem of refrigerant leak.
- **Non-Freon** : A system in which ammonia circulates as the primary refrigerant and CO₂ as the secondary refrigerant.
- **Energy Saving** : As a unit exclusively for the refrigerated warehouse, CO₂ 2.0 at Class F. Compared to conventional Freon refrigerants, about 20% energy saving.

Efforts to Reduce CO2



Case Study

10,000t Refrigerated Warehouse
Inside Temperature: -25°C

Power Consumption

< Conventional System >

317kW

< Hybrid Cooling System >

222kW

NH₃

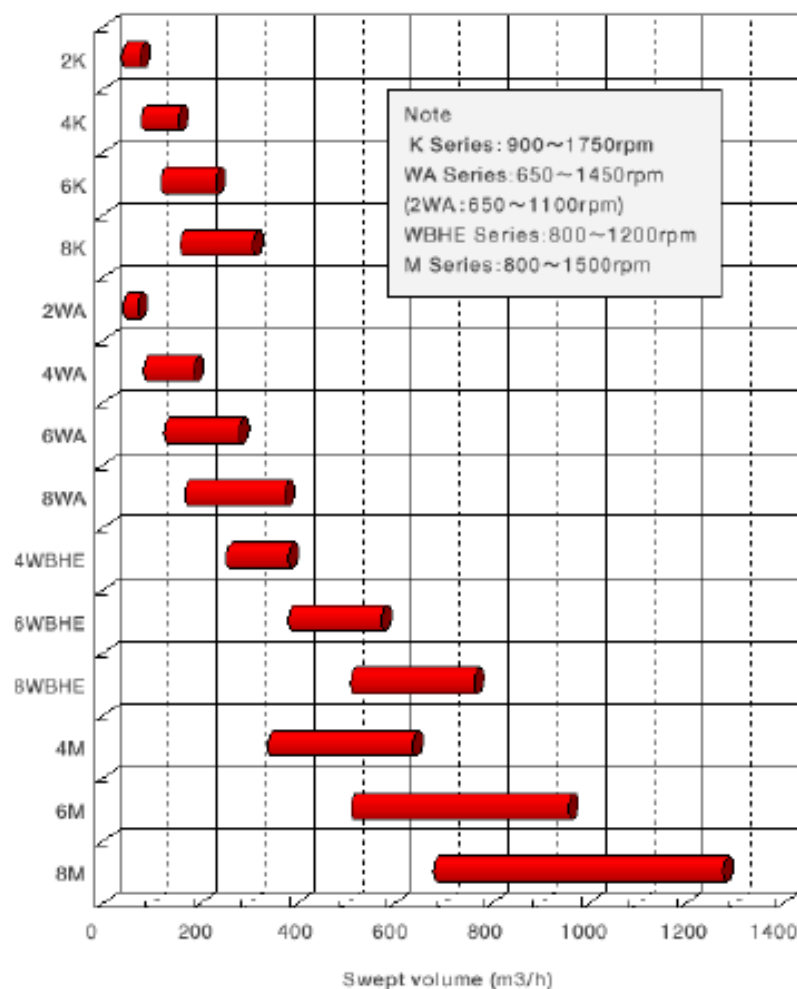
• NH₃ Compression Refrigeration



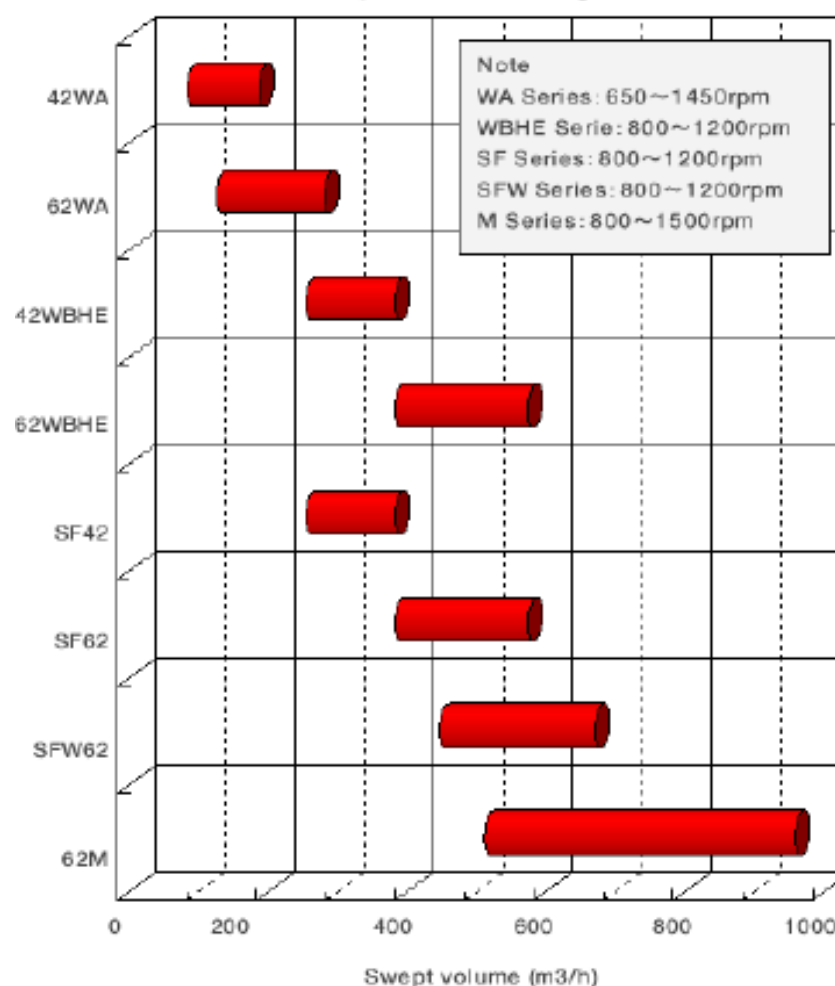
Ammonia

NH3 PISTON REFRIGERATION (15->1300 m3/hr)

MAYEKAWA Reciprocating compressors
Single-stage

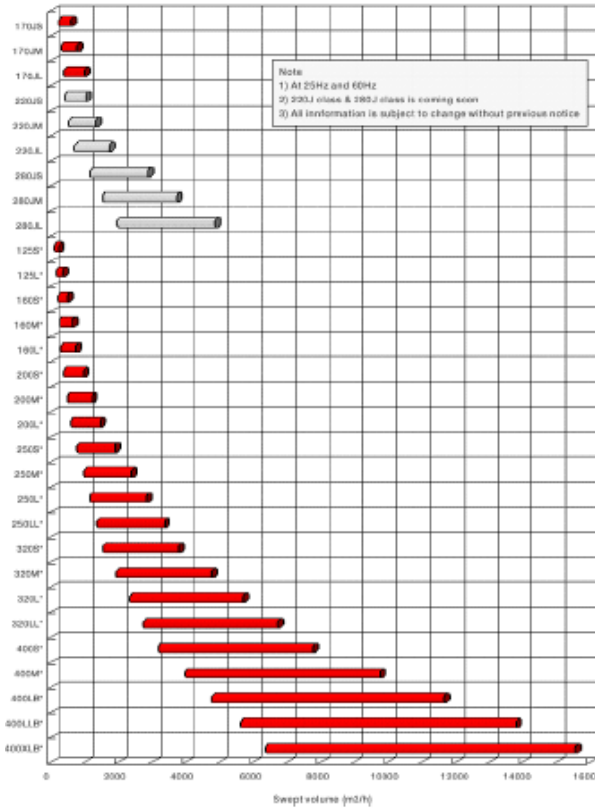


MAYEKAWA Reciprocating compressors
Compound two-stage

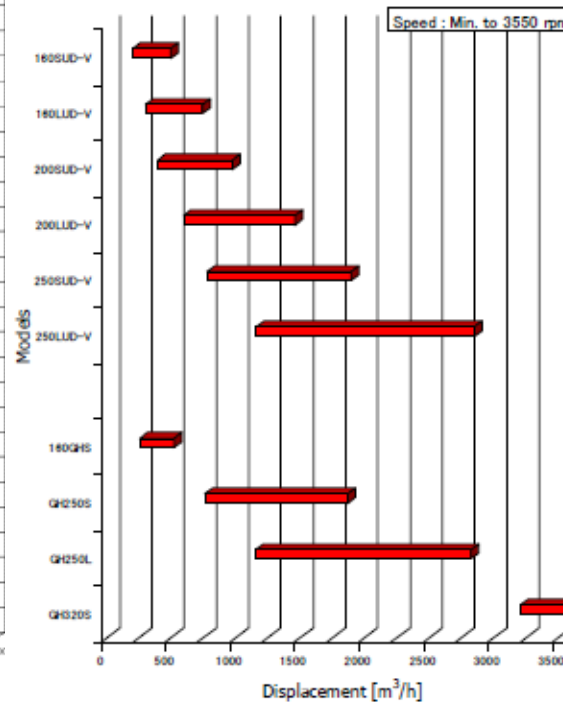


NH3 SCREW REFRIGERATION (200->15.600 m3/hr)

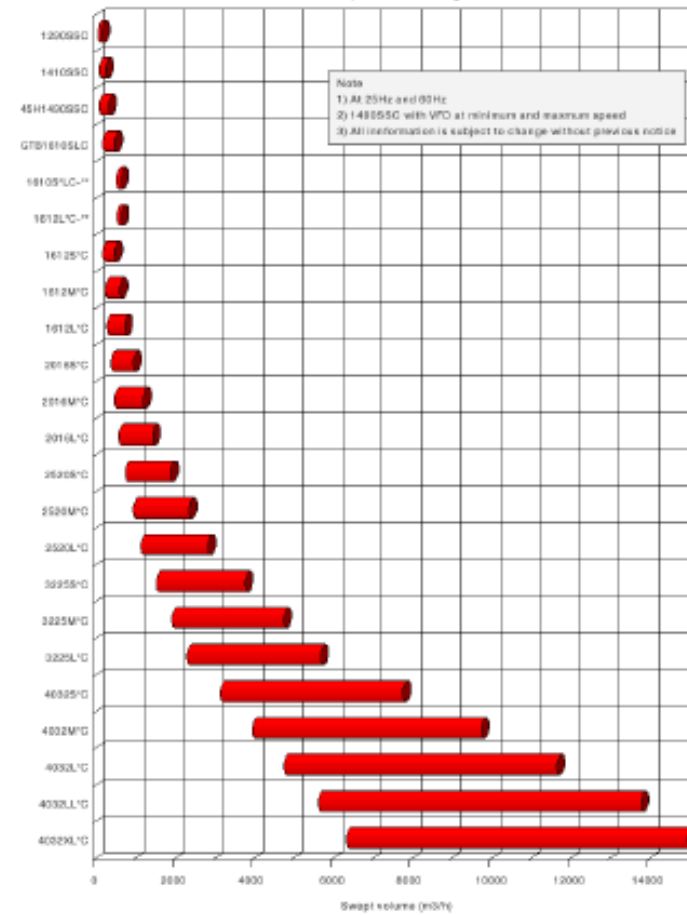
MAYEKAWA Screw compressors
Single-stage



MYCOM SCREW COMPRESSORS LINE-UP
Single-stage (2)



MAYEKAWA Screw compressors
Compound two-stage





NH3 COMPRESSION CO2 secondary brine REFRIGERATION

MYCOM

- | | |
|--------------------------|--|
| • INSTALLATION | 2005 |
| • HOURS OPERATION | 30.000 hours |
| • APPLICATION | 80.000m3 store |
| • OUTPUT NH ₃ | 1200kW -34°C NH ₃ |
| | CO ₂ (brine) 1200Kw -30°C CO ₂ |



NH3 COMPRESSION REFRIGERATION

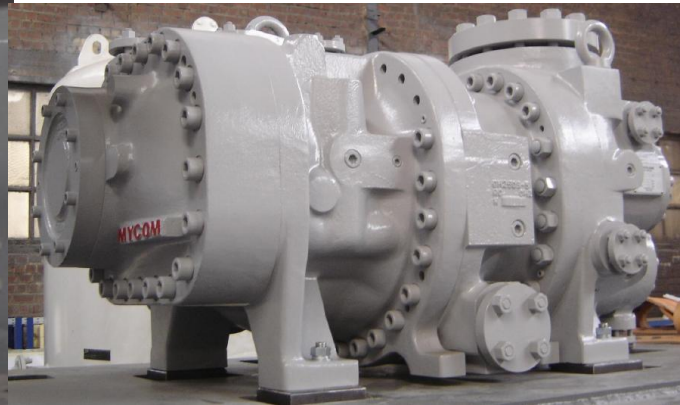
MYCOM



- | | |
|-------------------|----------------------|
| • INSTALLATION | 2003 |
| • HOURS OPERATION | 28.000 hours |
| • APPLICATION | ice cream production |
| • Freezing output | 3450kW -42°C |

NH₃

• NH₃ Compression Heat-Pump

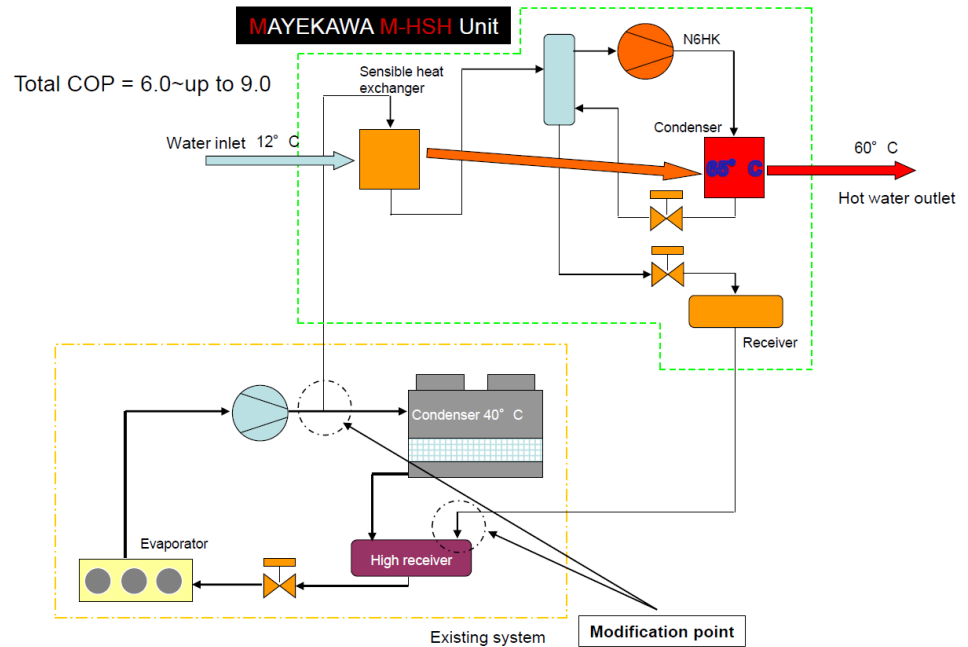


Ammonia

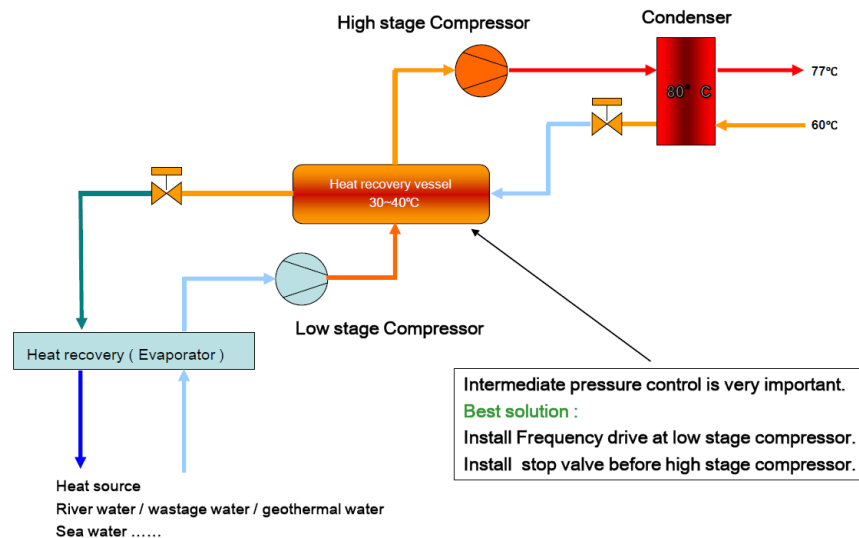
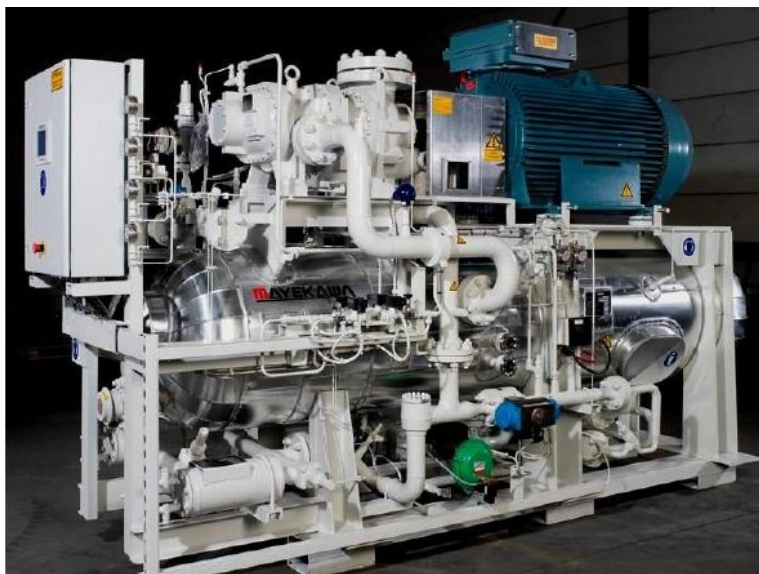


NH3 HEAT PUMPS

MYCOM



- | | |
|--------------------|-----------------|
| • INSTALLATION | 2008 |
| • HOURS OPERATION | 4.000 hours |
| • APPLICATION | meat processing |
| • Hot water output | 400kW 60°C |



- INSTALLATION 2009
- HOURS OPERATION 6.000 hours
- APPLICATION district heating
- Hot water output 2400kW 77°C



CO₂

- Hot water and Hot dry air supply Heat-Pump
- Source : Air and Water

**Carbon dioxide**

Industrial Hot Water Production Package

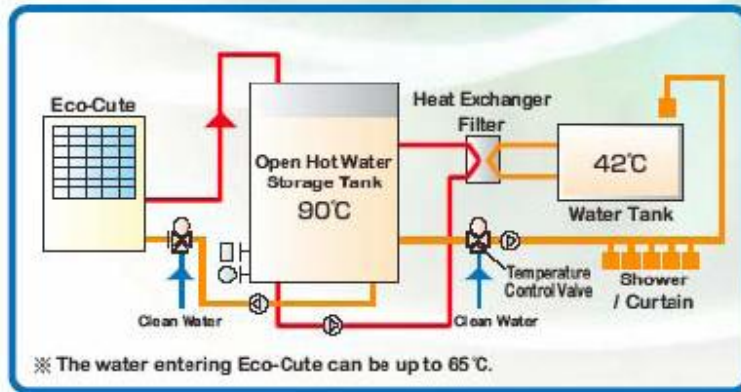
Awarded for: The 7th Electric-Load Leveling Equipments / systems [Heat Pump Thermal Storage Development Awards]



Water-Source Type is also available.



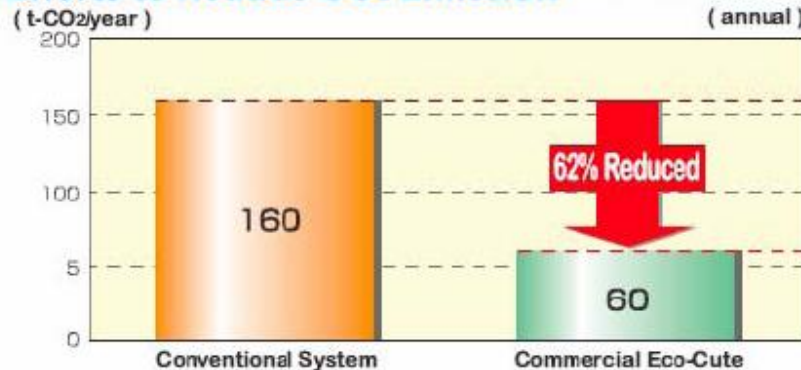
62% Reduction of CO2 Emission



Targets: Hospitals, hotels, welfare institutions, sports facilities, bathing facilities, facilities for boarding, food factories, etc.

- The best water supply ability in Japan (Air heat source 80kW, water heat source 90kW).
- Very little CO₂ emission, compared with equipments run by burning the energy source. Emission could be cut by more than 60% than heavy-oil boilers.
- 循環 heating operation (Water entering Eco-Cute at 65°C, exiting at 90°C).
- Flexible design of water supply system and storage tanks to meet your needs.
- Entering medium to large-scale water supply market as the electric equipment replacing hot-water boilers. The complete electrification is possible.

Efforts to Reduce CO₂ Emission



Case Study

A Company Housing where Hot Water Supply is 20m³/day
The Number of People: 200

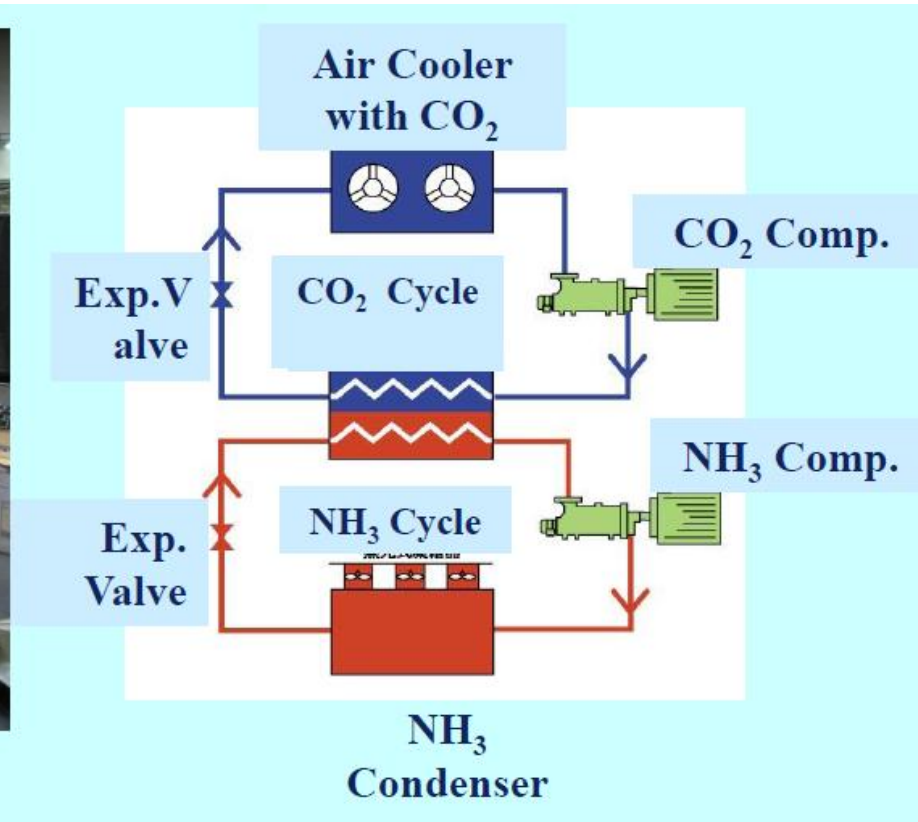
<Conventional System>	<Commercial Eco-Cute>
Fuel Oil Boiler	
Crude Oil Equivalent	Crude Oil Equivalent
59,040 ℓ /yr	22,153 ℓ /yr

CO2

- CO2 Compression Refrigeration



Carbon dioxide



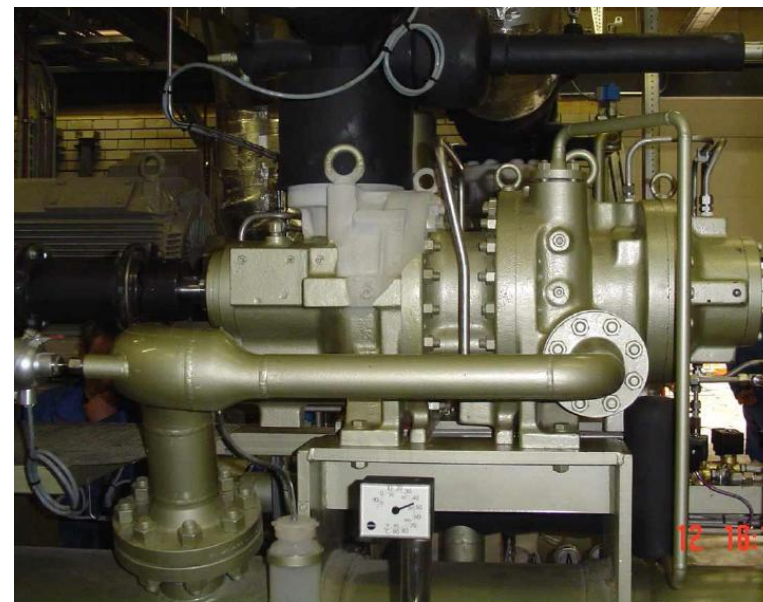
A. LOW TEMP. SIDE : FREEZING CAPACITIES

CO2 LIQUID T°	1xGH160	2xC200WHD	2xC6HK
-51 °C	1300 KW	2900 KW	
-41 °C	1800 KW		800
-31 °C	2000 KW		1000

B. HIGH TEMP. SIDE

NH3

7 x SCREW COMPRESSORS



- **INSTALLATION** 2005
- **HOURS OPERATION** 38.000 hours
- **APPLICATION** meat industry



- Mixed Refrigerants Heat-Pump
(Butane and Propane)

Hydrocarbon

Hydrocarbon Refrigerant Packaged Unit

2005
~2007 NEDO [Energy-Saving Non-Freon Air-Conditioning and Refrigeration System]

([Industrial Technology Development Subsidizing Company])



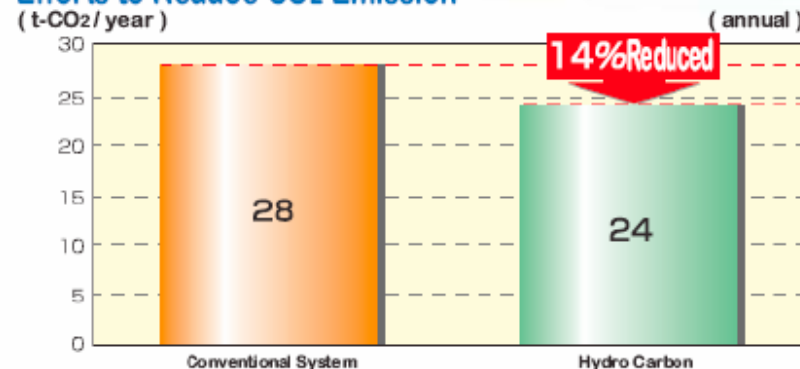
14% Reduction of CO2 Emission

Cooling C O P	COP=3.7 (Air-Cooled)
Heating C O P	COP=3.7 (Air-Source)
Supplying Water C O P	COP=3.3 (Supplying temperature 65°C, air-source)

Targets: Commercial / Industrial Air-Conditioning, Water-Supply

Supply Temperature	Applications	Suitable Markets
70°C	65°C Hot Water-Supply / Heating System	Food factories, hotels
50°C	45°C Heating System	Office buildings, factories
0°C	+7°C Chilled Water Chiller System	Office buildings, factories
-5°C	+2°C Chilled Water Chiller / Supercool Ice Making System	Food factories
-15°C	Ice on Coil Ice Thermal Storage System	Food factories

Efforts to Reduce CO2 Emission



Case Study

40USRT Chilled Water Supply Machine
Chilled Water Temperature : 7°C

Power Consumption

< Conventional System >
R134a
Chilled Water Supply Machine
43kW

< Hydro Carbon >
36kW

A purple rounded rectangle with a white border containing the text "H2O".

H2O

- Ad-sorption Chiller Utilizing Solar Energy

A horizontal bar with a purple-to-white gradient, ending in a solid purple section on the right containing the word "Water".

Water

Adsorption Chiller Packaged Unit

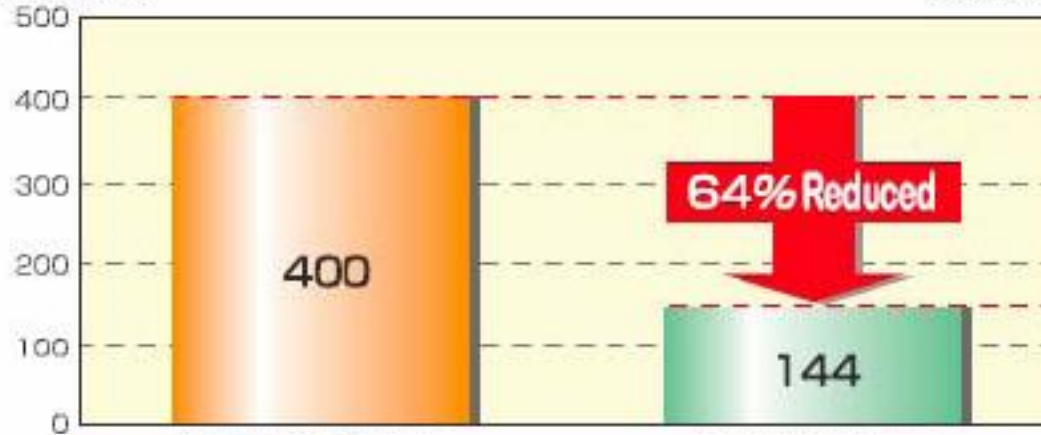
2005
~2007 NEDO [Research and Development of New System Utilizing Solar Energy]



Efforts to Reduce CO₂ Emission

(t-CO₂/year)

(Annual)



Case Study

100USRT Industrial Process Cooling
Cold Water Temperature : 9 °C

Power Consumption

<Conventional System>
R134a Cooling Water

100kW

<Adsorption Chiller>

36kW

AIR

- Air Cycle Refrigeration System
- For Low Temperature Applications
-50 ~ -120 °C

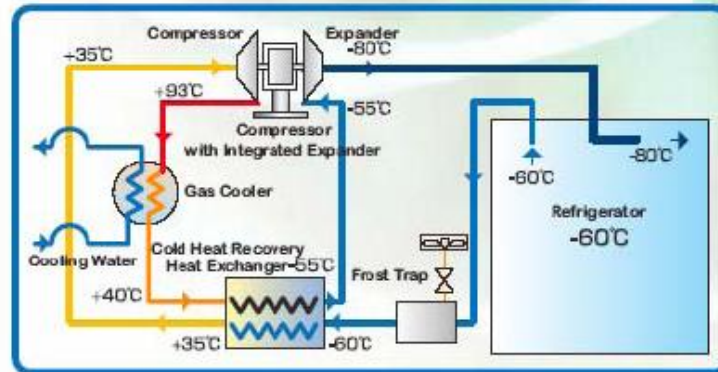
AIR

Air Cycle Refrigeration Packaged Unit

2003 Developed at [Technical Strategy for Rationalization of Energy Consumption Project]
~2005 NEDO



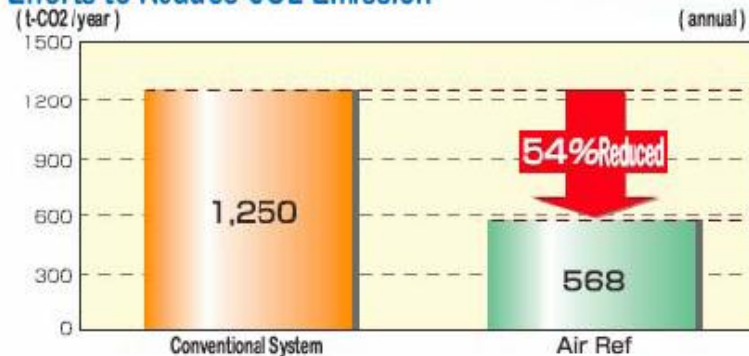
54% Reduction of CO2 Emission



Target: Ultra cold refrigerator for tunas and bonitos, rapid freezer, frost-破碎 etc.

- Using [Air] as the ultimate natural refrigerant, [Air Ref] is safe and eco-/people-friendly.
- Due to the turbo compressor with integrated expander, high COP can be achieved, saving energy by 50% comparing the conventional types.
- Due to its low operating pressure, exempt from legal regulations.
- Directly cooling the air, Air Ref does not require a fan coil unit or piping for refrigerant in the storage.
- Dehumidifying agent reduces frosting in the storage. Defrosting is not required.

Efforts to Reduce CO2 Emission



Case Study

2,000 ton Refrigerator
Interior Temperature : -60°C

Power Consumption

< Conventional System >
R22 2 Stage Compression Refrigerator

281kW

< Air Ref >

128kW

CONCLUSION

- MAIN GOAL :
‘zero and low GWP HCFC alternatives’
- GWP ‘NATURAL 5’ : 0 -> 3
- ODP ‘NATURAL 5’ : 0
- Field-examples : CO2 emission- & energy consumption reduction (approx.)

NH3 Newton3000	-30%
NH3 hot water	-60% (COP _h >2,5)
CO2 hot water	-62%
HC chilled water	-14%
ADSORPTION chilled water	-64%
AIR ultra cold air	-54%

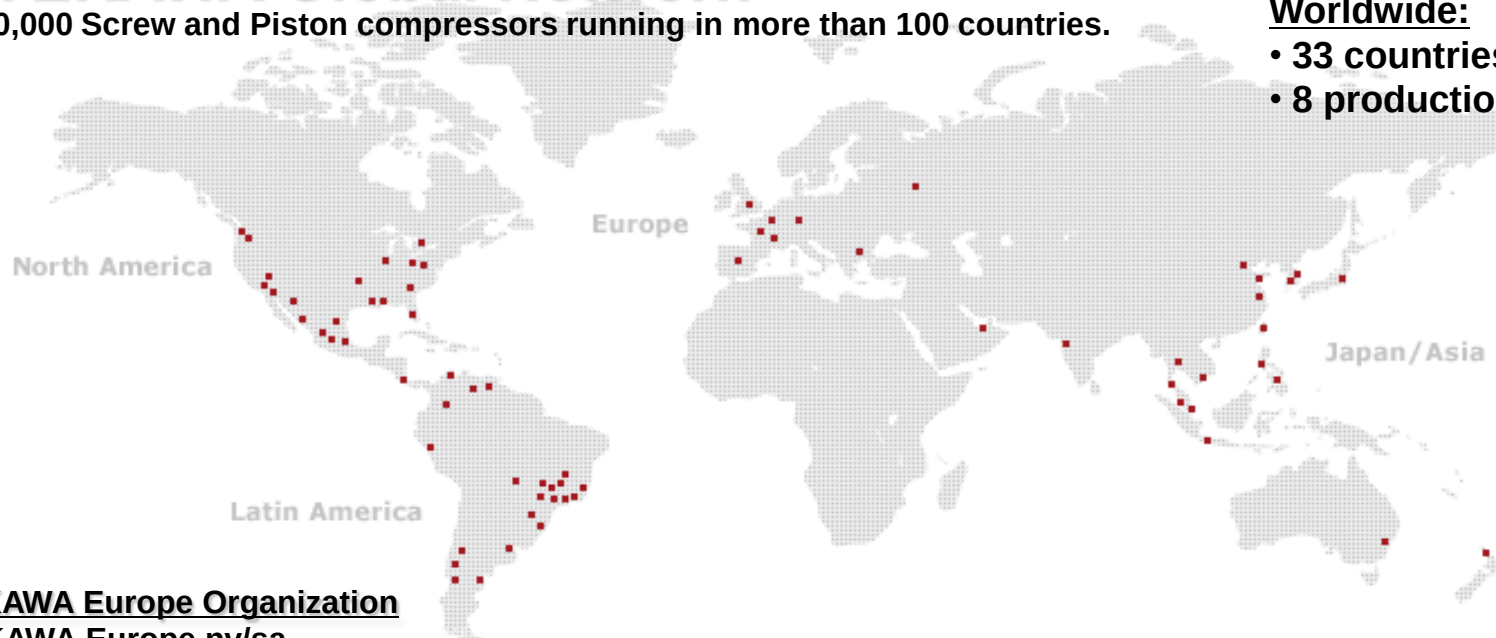
**THANKS FOR YOUR
ATTENTION!**

MAYEKAWA Global Network

Over 70,000 Screw and Piston compressors running in more than 100 countries.

Worldwide:

- 33 countries / 119 offices
- 8 production plants



MAYEKAWA Europe Organization

MAYEKAWA Europe nv/sa

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