

# Energy Efficient Refrigeration and Air-Conditioning Equipment Based on Natural Refrigerants

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# MOEJ Projects to Promote the Introduction of Energy-Efficient Refrigeration Technologies that Use Natural Refrigerants (FY 2008 to FY 2012)

## Introduction

Freezing/refrigeration equipment and air-conditioning systems are widely used in retail shops, factories, logistics centers, etc. In the recent years, new developments have been made in these sectors and the new equipment that is both energy-efficient and free from CFC, HCFC, or HFC, which are potent GHGs.

The Ministry of the Environment of Japan (MOEJ) has been providing financial assistance to the projects to introduce energy-efficient freezing/refrigeration equipment that uses natural refrigerants on the occasions of renewing the existing facility or newly building a new facility with a view to reducing the energy consumption in the operation of these facilities, CO<sub>2</sub> emissions from the energy consumption, and emissions of CFC, HCFC, and HFC at the same time.

## Subsidiary Rules

1. Eligible applicants for subsidy: Private companies
2. Projects eligible for subsidy: Projects to introduce energy efficient freezing and/or refrigeration equipment that uses natural refrigerants or similar equipment
3. Subsidization ratio: A maximum of one third of the cost incurred for the introduction of the eligible equipment that is incremental to the cost of the comparable HFC-based equipment, including the installation cost.

The following pages introduce 9 exemplary projects using different technologies in different situations in Japan.

# Showcase Refrigeration System Based on Zero ODP and Low GWP Refrigerant (CO2)

*AEON Retail Co., Ltd. is a general retail company with some 500 shops throughout Japan (as of February 2011).*

From the viewpoint of climate change prevention, it is important to reduce the emissions of HFC refrigerants whose GWP is much higher than that of CO2. It is expected that the use of equipment containing HFC as the refrigerant will increase significantly at supermarkets; since the leakage of refrigerants from freezing and refrigerating equipment in operation and at the end of commercial life is difficult to prevent completely, the development of freezing systems based on natural refrigerants is needed as a matter of priority. AEON is the first supermarket company in Japan that started the test use of freezing showcases based on natural refrigerants in 2009. After repeated improvements, the system has become sufficiently energy efficient for business use.



**AEON**

Place: Himeji Aeon Town Shop  
Company: AEON Retail Co., Ltd.  
Location: 435-4 Nobusue, Himeji City,  
Hyogo Pref., Japan  
Technology: CO2 refrigeration system  
Installation space:  
W 1,800 × D 900 × H 1,200 mm  
Facility: CO2-based refrigeration of 13 HP (1  
unit); reach-in showcase refrigeration  
system  
2 m (3 units)/1.5 m (2 units)

## AEON Natural Refrigerants Declaration

Aeon announced the Aeon Natural Refrigerants Declaration in November 2011. The declaration states that Aeon will progressively switch to natural refrigerant (CO2) for freezing and refrigeration cases throughout their Group stores, and that from 2015 on, all new stores will feature natural refrigerant systems.



CO2-based Showcases



Schematic Plan

- Energy consumption reduction: 25% (as compared with an R404A-based system of comparable performance)
- CO2 emission reduction: 15 tCO2/year (0.555 kgCO2/kWh)  
31 tCO2/year (from refrigerant leakage reduction as compared with an R-404A-based system of comparable performance containing 50 kg of R404A with a leakage rate of 16% during operation.)



# NH3-Based Highly Efficient Brine Cooling System

Highly Efficient and Energy-Saving Cooling System at a Beer Factory

*A pioneering system based on the combination of NH3 and highly efficient brine cooling system.*

Asahi Beer is the first company in Japan that has introduced a completely fluorocarbon-free factory (Nagoya Factory); it is known for its efforts for climate change prevention and environmental conservation.

In extending its experience of the fluorocarbon-free factory in Nagoya to other key factories, they adopted a highly efficient NH3-refrigerant cooling system combined with a brine (antifreeze coolant) cooling system.

For the purpose of cooling the heated brine, two NH3-based cooling units are installed in a cascade system, thereby achieving high efficiency.

When the temperature of the brine is not high, only one NH3-based cooling unit operates. In this flexible cooling system, the system operation efficiency has been enhanced.



Place: Asahi Beer Ibaraki Factory

Location: 1-1-1 Midori, Moriya City, Ibaraki Pref. Japan

Area: 387,855 m<sup>2</sup>

Technology: Large temperature difference brine cooling technology

Equipment: Outdoor brine cooling facilities, system control facility



## «Energy-saving»

- Energy consumption reduction (converted in electricity)

1,146,995 kWh/year

## «CO2 emission reduction»

- CO2 emission reduction (energy-source CO2 reduction)

786 tCO<sub>2</sub>/year (electricity 0.555 kgCO<sub>2</sub>/kWh)



This project was MOEJ's model project in FY 2005 for the promotion of energy-efficient equipment using natural refrigerants and other alternative refrigerants.

# Highly Efficient System Based on NH3 and CO2 Refrigerant

Latest Cooling System for Logistics Center

## **24-hour operation logistics center demonstrating both “safety” and “energy efficiency”.**

At the logistics centers of Japanese Consumers' Cooperative Union (CO-OP), the lighting inside all the centers has been replaced with LED and is equipped with a sensor system that turns on and off the lighting automatically.

A latest freezing system based on NH3/CO2 is used in which a small quantity of NH3 is charged, addressing safety concerns.

In addition to the renewal of the cooling system, photovoltaic panels of 600 kW were installed on the entire roof for renewable energy use.



**co-op**

Company: Japanese Consumers' Cooperative Union

Location: 1-190 Minogochō Hongo, Onomichi City,  
Hiroshima Pref. Japan

Area: 18,118 m<sup>2</sup> (total floor area)

Facility: 24-hour operation logistics center

Equipment:

(-25 °C) NH3/CO2 cooling system

(+5 °C) NH3/CO2 cooling system

(+5 °C) dehumidifying and floor heating system



Latest logistics center with photovoltaic system

### «Energy-saving»

- Energy consumption reduction (converted in electricity)

374,024 kWh/year

### «CO2 emission reduction»

- CO2 emission reduction (energy-source CO2)

234.9 tCO2/year (electricity: 0.555 kgCO2/kWh)

This project was MOEJ's model project in FY 2009 for the promotion of the introduction of energy-efficient equipment using natural refrigerants and other alternative refrigerants.



# Highly Efficient System Based on NH3 and CO2 Refrigerants

Latest Cooling System for Logistics Center

*An advanced energy-efficient logistics center free from CFC, HCFC, and HFC.*

Yokorei Co., Ltd. gives consideration to the conservation of the global environment in its operation in logistics business.

Its efforts for the reduction of environmental load include the acquisition of a Green Management Certificate in all of its facilities in Japan and the change to natural refrigerants at its logistics centers.

In addition to the renewal of the cooling system, CO2 reduction technologies such as the photovoltaic system, highly efficient lighting devices, and hybrid vehicles are adopted.

Hokuko Logistics Center



Company: Yokorei Co., Ltd.

Location: 1-1-22 Shirotzu, Hokuko, Konohana-ku, Osaka City, Japan

Scale: 27,000 cooling tons

Facility: Freezing and refrigerating logistics center

Equipment: -25°C freezing system  
+ 05°C refrigeration system  
positive pressure ventilation system, etc.



NH3/CO2 refrigeration system (+ 05°C)



Warehouse Temperature (-25°C)



Photovoltaic System

## «Energy-saving»

- Energy consumption reduction (converted in electricity)  
570,000 kWh/year

## «CO2 emission reduction»

- CO2 emission reduction (energy-source CO2)  
413.3 tCO2/year (0.555 kgCO2/kWh in electricity)

# Highly Efficient, Energy-Saving Food Freezing System

Food Freezing System Using the Natural Refrigerants, CO<sub>2</sub>/NH<sub>3</sub>, in Food Processing Factory

A freezing system that uses NH<sub>3</sub>, whose GWP is 0, as the refrigerant was selected to freeze cooked foods in the construction of a food processing factory.

NH<sub>3</sub>, existing naturally, neither destroys the ozone layer nor has climate impact. The use of CFC, HCFC, or HFC was avoided and energy-saving was achieved by reducing electricity consumption through the use of a highly energy-efficient freezing facility.

In the food product area, odorless and harmless CO<sub>2</sub> is used as the secondary refrigerant, achieving a safe, highly efficient system based completely on natural refrigerants.



AQLI FOODS Yubari Factory



Company: AQLI Foods Yubari Factory

Location: 510-11 Numanosawa, Yubari City, Hokkaido Pref., Japan

Manufacturer: Toyo Engineering Works, Ltd.

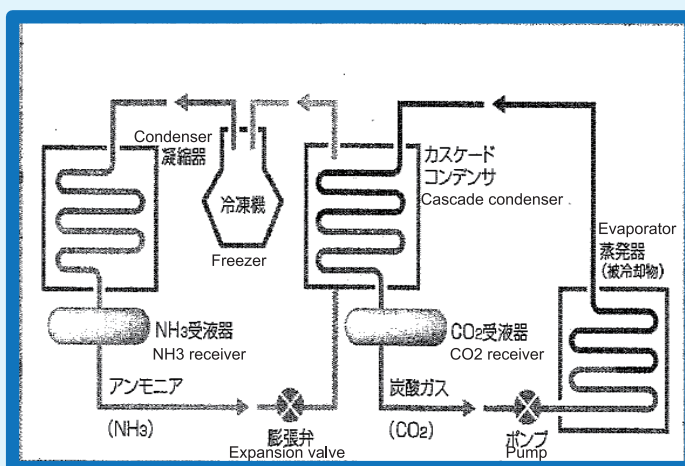
Equipment: CO<sub>2</sub>/NH<sub>3</sub>-based freezing system

Use: Freezing of cooked foods

Installation cost: 189.3 million JPY

Annual electricity consumption: 536,643 kWh

Freezing capacity : 229.48 kW



Schematic Plan

## 《Energy-saving》

- Energy consumption reduction (converted in electricity)  
246,343 kWh/year (204.7 tCO<sub>2</sub>/year)



NH<sub>3</sub> Cooling Machine

This project was MOEJ's model project in FY 2007 for the promotion of the introduction of energy-efficient equipment using natural refrigerants and other alternative refrigerants.



# Air-Based Freezing System

## Super Low Temperature Refrigerated Warehouse

*Creating the -60°C environment based on the ultimate natural refrigerant, “air” .*

**Quality:** A high degree of freshness of stored goods is maintained because the temperature fluctuation is low with no defrosting in the warehouse and the air flow is so little that the draft is impalpable.

**Operation:** No leakage issue exists because no synthetic refrigerants are used.

**Energy efficiency:** The cooling load within the warehouse is significantly reduced with no heat from fans or defrosting.

**Leakage:** An epoch-making freezing system that has no leakage of the refrigerant without compromising high quality maintenance.



No. 2 Refrigerated Warehouse



Air-Based Freezing System

Place: Fukazawa Reizo K.K. Head Office. No.2 Refrigerated Warehouse  
Location: 860 Dobara, Yaizu City, Shizuoka Pref., Japan  
Capacity: 8,000 t  
Facility: -60°C super low temperature refrigerated warehouse (tuna and bonito)  
Equipment: Air-based freezing system

### «Energy-saving»

- Energy consumption reduction (34% compared to the historical level)  
1,115,063 kWh/year

### «CO2 emission reduction»

- CO2 emission reduction 559 tCO2/year (Breakdown)
  - Energy-source CO2 reduction: 380 tCO2/year  
\*Electricity 0.341 kgCO2/kWh
  - Refrigerant leakage CO2 reduction: 179 tCO2/year  
\*Calculated on the assumption that the GWPs of R-22 and R-23 are 1,780 and 14,800, respectively and that the refrigerant charge is 90 kg and the leakage rate is 12%.



Inside the Refrigerated Warehouse

This project was funded by NEDO in FY 2008 as a project to assist business operators with energy use rationalization.



# Cooling and Heating Air-conditioning System Based on Adsorption Freezing Facility and Solar Heat

Next-Generation Cooling and Heating System Based on Renewable Energy (Solar Heat)

*An air-conditioning system using “water” as the refrigerant.*

Waseda Setsuryo Junior High School and High School of Waseda University Group introduced a cooling and heating air-conditioning system based on a newly developed adsorption freezing machine that uses the renewable energy (solar heat) as the heat source.

An air-conditioning system that addresses the latent heat and the sensible heat separately was set up based on a new adsorption freezing machine in combination with radiant panels and desiccant dehumidifier and installed for 6 classrooms. In summer, dry and cool air is provided without drafts; in winter, feathery warm air is provided with no palpable air flows.

The above-mentioned system is also a good textbook for environmental education as an example of renewable energy use in daily life. It is expected to contribute to the development of environmentally-friendly attitudes of future generations and to create the momentum for the low carbon manufacturing.



Place: Waseda Setsuryo Junior High School and High School

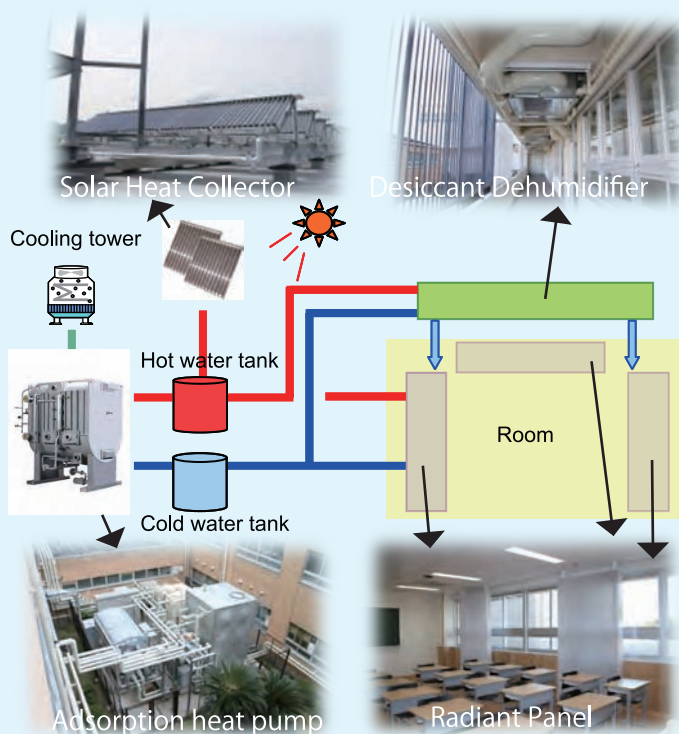
Manufacturer: Mayekawa Mfg. Co., Ltd.

Location: 7-20-1 Shukunosho, Ibaraki City, Osaka Pref., Japan

Scale: 6 classrooms

Facility: Cooling and heating air-conditioning system based on solar heat

Equipment: Adsorption heat pump, solar heat collector, desiccant dehumidifier, radiant panel, etc.



## «Energy-saving»

- Energy consumption reduction (converted in crude oil)  
22 kl/year

## «CO2 emission reduction»

- CO2 emission reduction (energy-source CO2 reduction)  
51 tCO2/year (electricity: 0.555 kgCO2/kWh;  
natural gas: 2.29 kgCO2/m3h)

This project was funded by the MOEJ in FY 2010 and FY 2011 as a project to develop technologies to address climate change.

# Hybrid Cooling and Heating System Based on Solar Heat and Natural Chiller

Stable and comfortable air-conditioning system based on clean, solar heat and environmentally friendly natural refrigerant chiller

*Kawasaki Thermal Engineering commercialized the natural refrigerant chiller (absorption chilled/hot water supplier) in 1968 for the first time in the world.*

*In June 2010, it started the sales of a solar and natural refrigerant chiller specialized for solar heat use.*

## 《Special features of the system》

### Environmentally friendly natural refrigerant

Instead of using CFC, HCFC, or HFC, which have high GWP, this air-conditioning system uses naturally-occurring “water” as the natural refrigerant.

### Stable and comfortable air-conditioning despite the use of variable solar heat

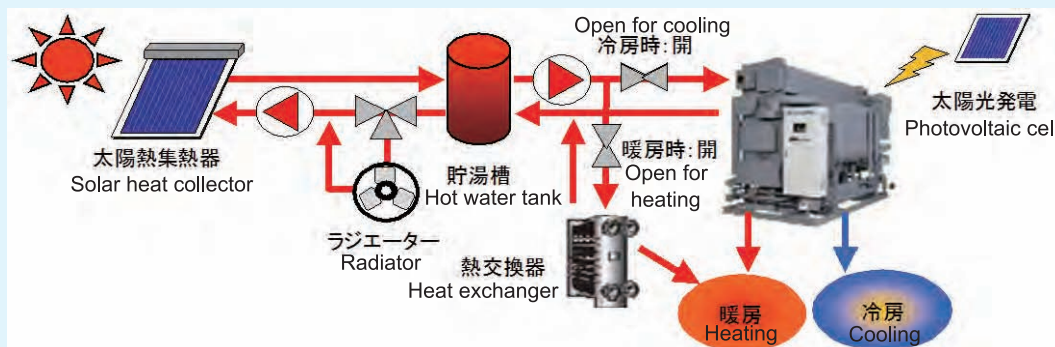
This natural refrigerant chiller is a convenient machine that can utilize variable heat sources such as solar heat, equipped with a back-up heat source based on clean, natural gas. While solar heat is utilized as the primary heat source, efficient back-up is provided when sufficient heat is not available due to the weather condition. No compromise with comfort and convenience in pursuit of environmental benefits.

### Contribution to the leveling of electricity load

Because this natural refrigerant chiller uses natural gas, it is possible to reduce dependence on electricity, which contributes to avoiding power shortage at electricity consumption peaks.



Solar and Natural Refrigerant Chiller



Place: Kawasaki Thermal Engineering. Shiga factory.

Manufacturer: Kawasaki Thermal Engineering.

Location: 1000 Aojicho, Kusatsu City, Shiga Pref., Japan

Scale: Cooling and heating of a factory (4,600 m<sup>2</sup>) and a two-story office building (1,000 m<sup>2</sup>)

Facility: Cooling and heating air-conditioning system that uses solar heat

Equipment: Vacuum tube heat collector: 160 sheets (260 m<sup>2</sup>)  
natural gas-fired, solar, and natural refrigerant chiller (capacity: 739 kW)  
control system ("e-CopSaver")

## 《Energy-saving》

○Energy consumption reduction: 27% (the total amount of electricity and natural gas)

○CO<sub>2</sub> emission reduction: 19 tCO<sub>2</sub>/year

\* The total consumption of electricity and natural gas of the entire system, including the control system, as compared with the conventional system.



# Introduction of Propylene Refrigerant-Based System

Effort toward a Low-Environmental-Load Chemical Plant

*New-generation chemical plant freezing unit using a non-fluorinated refrigerant.*

At a polypropylene production plant of the Oita office of SunAllomer Ltd., a 30-year-old absorption freezing unit was replaced with a new freezing unit that uses propylene as the refrigerant on the opportunity of the production plant expansion.

Energy efficiency has increased by removing the steamer-based refrigerant recycling process that existed in the old absorption freezing unit. In addition, a system that uses a non-fluorinated refrigerant was introduced, achieving a low environmental load from the freezing unit.

The introduction of this system is part of the on-going efforts of SunAllomer Ltd. to be a chemical company that gives consideration to the natural environment and local people. It will continue the conversion of facilities for greater energy-efficiency and lower environmental load.



Place: SunAllomer Ltd. Oita office.

Location: 2 Nakanosu, Oita City, Japan

Cooling capacity: 612 kW

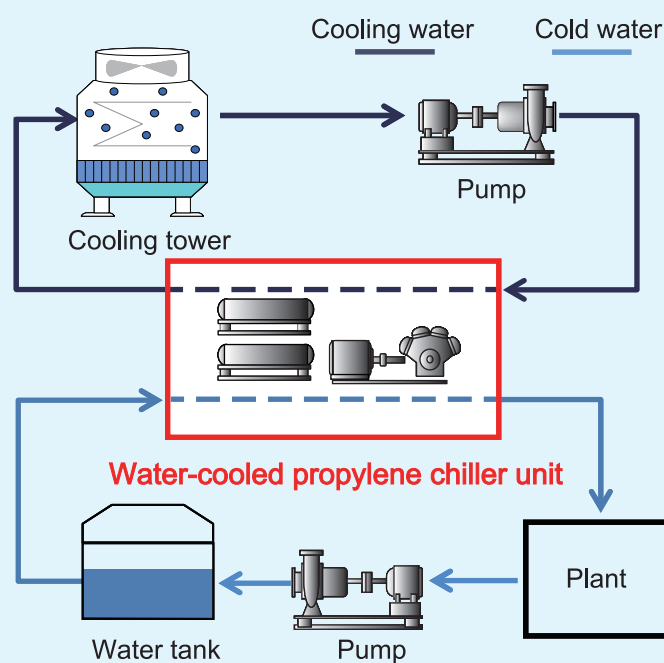
Facility: Propylene-based freezer

Equipment: Cooling tower, cooling water pump, water-cooled propylene chiller unit, cold water tank, etc.



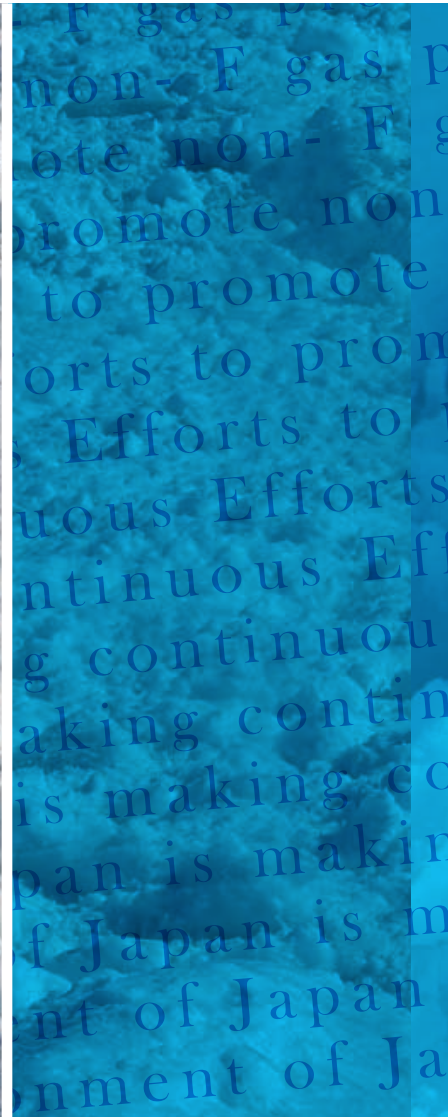
## «CO2 emission reduction»

- CO2 emission reduction (related to refrigerant leakage)  
17.1 tCO2/year
- CO2 emission reduction (related to energy-source CO2)  
312 tCO2/year (0.472 kgCO2/kWh electricity)
- \* As compared with an R-407C-based cooling facility.



Schematic Figure of Propylene-Based Freezer

This project was MOEJ's model project in FY 2009 for the promotion of the introduction of energy-efficient equipment using natural refrigerants and other alternative refrigerants.



**Ministry of the Environment  
Government of Japan**

**Office of Fluorocarbons Control Policy**



Ministry of the Environment  
JAPAN