

ATM0sphere Asia 2014

Summary Report

technology & innovation

natural refrigerants

**Summary Report
International Workshop**

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 **ATMO
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natural refrigerants

ATMOsphere Asia 2014

**Summary Report
International Workshop**

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**MARC CHASSEROT**

Chairman ATMOsphere Asia 2014,
shecco

ATMOsphere Asia 2014 was a big success

ATMOsphere Asia brought together close to 180 government experts, end-users and industry leaders for three days to discuss the future of natural refrigerants across Asia. To our knowledge this was the biggest ever gathering of natural refrigerant expertise to be held in Tokyo.

We learned about the latest innovations related to world-leading Eco Cute CO₂ hot water heat pumps (stable and with high-efficiency in challenging climatic conditions) as well as technologies for industrial refrigeration (packaged low-charge, highly efficient ammonia/CO₂ solutions and absorption chillers using water as a refrigerant) ... to name a few.

There were many highlights of ATMOsphere Asia and a short introduction cannot do justice to all of them. However, if I take a step back, there was one key message to take away from this first-ever ATMOsphere Asia conference: "Natural Refrigerants are coming to commercial refrigeration in Japan. Is this the 'Eco Cute' moment for Food Retail (for convenience stores as well as large store formats) to bring together all major actors with one clear focus?"

We now have an ecosystem to drive this change. We have the Ministry of Economy (METI) developing new F-Gas legislation that will open up opportunities for natural refrigerants; and we have the Ministry of Environment (MOE) providing subsidies and incentives to end-users and manufacturers using natural refrigerants, which will accelerate this trend. We have more and more end-users testing these new solutions following the lead of retailers like Lawson and Aeon. And importantly, we have more and more suppliers offering different solutions to compete with market-leader Panasonic.

All of these decision-makers attended ATMOsphere Asia 2014. Judging by the conversations that took place, we think this 'Eco Cute' moment will happen.

You can count on shecco Japan and ATMOsphere Asia to support this 'game changing' trend.

See you next year!

About ATMOsphere Asia 2014

Aiming to support the adoption of natural refrigerant technology in Asia and beyond, the first-ever ATMOsphere Asia conference on natural refrigerants brought together around 180 participants and heard from 38 speakers. The event provided a unique platform to exchange information and experience in natural refrigerant-based technology for the refrigeration and air conditioning industry. Presentations from end-users, policy makers and academics discussed the national and international legislative measures that could create opportunities for natural refrigerants, and talked about the very latest market trends and technologies using CO₂, ammonia, hydrocarbons, water and air as refrigerants in commercial and industrial refrigeration, air conditioning and heating. On the third day of the conference participants were invited to choose between two site visits, the first combining a visit to AEON's flagship mall in Makuhari and a MaxValu supermarket, both of which featured Panasonic transcritical CO₂ refrigeration systems. The second site visit combined a tour of Mayekawa's Moriya factory and trip to the Asahi Breweries in Ibaraki, which uses Mayekawa equipment.

* 10 years ago, the Japanese government, utility providers and industry came together to introduce CO₂ Hot Water Heat Pumps, known as Eco Cute. With over 4 million units sold this last decade, it has now become the 'best' example of natural refrigerants becoming a 'standard' technology.

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policy dimension



MARC CHASSEROT

shecco (Session Chair)



ALEXANDRA MARATOU

shecco



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(MOFA)



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Ministry of the Environment
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Japan Refrigeration & Air
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New Energy & Industrial Technol-
ogy Development Organization
(NEDO)

Focusing on both Japanese and international dimensions, the two Policy Sessions at the ATMOsphere Asia 2014 conference on natural refrigerants provided an overview of current legislation as well as future outlooks. The legislative landscape in Japan is changing, with the priority of the Japanese government aiming at stabilising f-gas emissions through amending the country's fluorocarbon regulations, as well as providing €36 million in subsidies for incentivising natural refrigerants. An update on Montreal Protocol developments, opportunities for deploying natural refrigerants in developing countries, as well as the review of the EU Regulation on fluorinated gases, were also discussed.



policy dimension

"Japanese companies can get over any obstacle with great effort and new technologies. [...] It is expected that the new [F-Gas] Act and its detailed guidelines will be a trigger for Japan's innovative and positive effort to receive appropriate appreciation, not only in Japan but also all over the world."

Masafumi Oki,
Japan's Ministry of Economy, Trade and Industry (METI)

Imminent revised Japanese f-gas legislation to increase operational cost of HFC equipment

New policy measures for reducing emissions of fluorinated gases in Japan were the focus of the presentations by Motoyuki Kumakura from the Japanese Ministry of Environment (MOE) and Masafumi Oki from the Ministry of Economy, Trade and Industry (METI). The main motive for the revision of Japan's fluorocarbon regulations promulgated in June 2013 has been the steep increase in emissions of fluorinated gases as well as findings of high leakage rates from commercial air conditioning and refrigeration equipment. The amended Act currently under discussion will therefore extend its focus from recovery and destruction measures to cover the whole life cycle of fluorinated gases, specifically the manufacturing of HFCs, equipment containing HFCs and the use of such equipment.

While taking into account energy efficiency, safety and economic affordability, manufacturers and importers of certain refrigeration and air conditioning systems will be requested to reduce the climate impact of their equipment by deploying non-HFC refrigerants and other low Global Warming Potential (GWP) refrigerants. Such measures will be based on the so-called Top Runner approach with sector-by-sector targets. In addition, f-gas manufacturers and importers will need to carry out a HFC phase-down by means of producing lower GWP refrigerants.

The scope and frequency of leak check requirements are also currently being discussed, according to Kumakura. The development of guidelines and standards will be finalised in the first half of 2014 with the revised Act anticipated to enter into force in April 2015.

Japanese end-users can benefit from €36 million in subsidies for natural refrigerant technology

Apart from the legislation limiting the use of f-gases, Kumakura from the Ministry of the Environment outlined the government subsidy scheme encouraging operators to use natural refrigerants. From the 2014 fiscal year the budget of the programme will increase significantly to a total of ¥5 billion (about €36.4 million) to support the use of natural refrigerants in:

- Refrigerated warehouses, covering 50% of investment cost,
- Retail store showcases, covering 1/3 of investment cost,
- Other refrigeration and AC equipment – covering 1/3 of the cost difference between natural refrigerant equipment and the equivalent HFC-based one.

"I would encourage the operators of cold stores, supermarkets and convenience stores to be proactive in applying for this [Japanese government subsidy] programme."

Motoyuki Kumakura,
Japan's Ministry of Environment (MOE)

The Ministry will be accepting applications by operators in April 2014, with a view to approve these around June 2014. Kumakura invited the end-users to take advantage of the support scheme: "I would encourage the operators of cold stores, supermarkets and convenience stores to be proactive in applying for this programme."

Need for revision of Japan's High Pressure Gas Safety Act

Some end-users and system manufacturers called for a revision of the High Pressure Gas Safety Act, the law which regulates the production, storage, sale, transportation and other matters related to the handling of high pressure gases, their consumption as well as the manufacturing and handling of their containers. Participants noted that this law is out of date and does not reflect the situation in the market, therefore, unnecessarily restricting the manufacturing and import of larger CO₂ refrigeration systems, e.g. for larger supermarkets.

The High Pressure Gas Safety Act and associated Ministry Ordinances, also specify safety measures for the use of hydrocarbon refrigerants in stationary applications, such as air conditioning and refrigeration, for example requiring explosion-proof structures. Although these additional requirements are not prohibitive to employing hydrocarbons, there seems to be low acceptance and public awareness in Japan on the possible safe use of hydrocarbons in applications other than domestic refrigerators and vending machines. For example, there is an untapped potential in Japan for using hydrocarbons in stand-alone refrigeration equipment in supermarkets and convenience stores. According to the presentation at ATMOsphere Asia by Bill Ho from AHT Cooling Systems, there are many design techniques applied to hydrocarbon systems to ensure their safety, such as the use of hermetic compressors. To date, AHT has supplied more than 530,000 cabinets with R290 all over the world, including in a number of Asian countries, and no incident has ever been recorded.

EU F-Gas Regulation and growing trend towards HFC taxes in Europe

Turning the focus to Europe, Alexandra Maratou, Deputy Public Affairs Manager at shecco, briefed the audience on the revision of the EU F-Gas Regulation, and the compromise deal recently reached among the European institutions, a topic that is being closely followed in Japan. Among all the measures covered by the F-Gas Regulation, HFC bans will play the most important role in terms of giving the industry a clear signal to move away from HFCs and accelerate the market uptake of natural refrigerants.

Looking at regional activities in Europe captured in the recent shecco report the ["Guide: HFC taxes & fiscal incentives for natural refrigerants in Europe"](#), Maratou showed that at least 13 countries have considered or adopted taxes on fluorinated gases or fiscal incentives for natural refrigerants. She argued that the acceptance of HFC taxation in Europe is increasing, but also that globally there is a growing trend towards introducing measures that limit the use of high GWP refrigerants or incentivise natural refrigerant technologies.

Opportunities for promoting natural refrigerants internationally

In his presentation, Takeshi Furutani from the United Nations Industrial Development Organisation (UNIDO) introduced UNIDO's activities and its efforts to promote green growth in emerging and developing countries.

<http://www.publications.shecco.com/publications/view/8>

He explained that the activities of the Tokyo-based UNIDO Investment and Technology Promotion Office (ITPO) focuses on green technology transfer from Japanese companies to help address sustainability challenges in developing countries. In addition to organising events the Tokyo ITPO has a green technology database listing 22 technologies.

Talking to an audience with a large number of natural refrigerant industry representatives, Furutani emphasised: "I hope that the ITPO office in Tokyo can promote the dissemination of important green technologies such as natural refrigerants."

Kumakura from the Ministry of Environment also discussed government support opportunities for implementing projects with natural refrigerants in developing countries through Japan's Joint Crediting Mechanism (JCM). The energy savings and f-gas emissions reduction realised by such projects will translate into emissions reductions credits under Japan's Joint Crediting Mechanism (JCM) and count towards meeting Japan's greenhouse gas reduction targets.

"This year [2014], the discussions on possible ways to avoid high GWP alternatives to ozone depleting substances will intensify more than ever, and there will be a chance for promoting climate friendly technologies, including natural refrigerants, as strong candidates globally and domestically."

Kazuhiro Takahashi,
Japan's Ministry of Foreign Affairs
(MOFA)

Finally, Kazuhiro Takahashi from Japan's Ministry of Foreign Affairs (MOFA) highlighted the international dimension, arguing that Japan has always been active in promoting climate-friendly technologies within the Montreal Protocol debates.

"This year [2014], the discussions on possible ways to avoid high GWP alternatives to ozone depleting substances will intensify more than ever and there will be a chance for promoting climate friendly technologies, including natural refrigerants, as strong candidates globally and domestically," said Takahashi, highlighting the upcoming 34th Open-Ended Working Group meeting of the Parties to the Montreal Protocol and the workshop on management of HFCs to be held in July 2014.

Panasonic

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due to refrigerant
leakage

CO₂ refrigeration systems

CO₂
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38 tons

Reduction effect
of

61%

Calculation conditions:
1 refrigeration unit (COU-CS2000MFV-T), 6 showcases (FLD-EX0377LC),
with 20m of connecting pipes. Assuming GWP 3920 of the R404A freezing,
CO₂ as 1. The annual leakage is calculated at 16%.



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market trends



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Sanden



KUNIAKI (NICK) KAWAMURA

Mayekawa



SHINICHIROU UTO

Lawson



HIROAKI SUZUKI

AEON



IAN CROOKSTON

Sobeys



YOSHINARI OKUYAMA

Coca-Cola Tokyo Research & Development



BILL HO

AHT Cooling Systems



ROLF CHRISTENSEN

Alfa Laval



PEIZHONG CONG

SWEP Japan

During the Market Trends session and also many of the other ATMOsphere Asia 2014 presentations, key Japanese system manufacturers, suppliers and food retailers discussed the latest market developments for natural refrigerant technologies in Japan and beyond.

In addition to the latest data on the number of natural refrigerant commercial refrigeration installations, CO₂ heat pumps and ammonia industrial refrigeration systems, many industry representatives discussed, in particular, the shift towards CO₂ in commercial refrigeration in Japan, a trend already evident at HVAC&R Japan 2014, which was held the week before ATMOsphere Asia 2014. With solutions presented by Panasonic, Sanden and Nihon Netsugen, the increasing innovation and competition in this market was brought to the forefront. For heat pumps, Eco Cute remains a leading choice for hot water heating in Japan.



market trends

Nina Masson, Head of Market Research at shecco, chaired the ATMOsphere Asia 2014 Market Trends session and presented during the End User Panel. Both of these sessions gathered perspectives from leading Japanese system and component suppliers and food retailers on the latest market trends for natural refrigerants worldwide.

"This industry is growing and is becoming more important in terms of employment, competitiveness and supply of the components."

Nina Masson,
shecco

GLOBAL TRENDS AND DEVELOPMENTS

Nina Masson contends that natural refrigerant solutions for many different applications, world regions and climates are already available.

Worldwide, Alfa Laval has sold more than 4,700 CO₂ transcritical (TC) heat exchangers and more than 150 units in Japan.

Europe: natural refrigerants technologies available for nearly all HVAC&R sectors by 2020

At least 430 companies actively provide natural refrigerant-based solutions, products and services in Europe today, with Germany, Italy, Denmark and the UK taking the lead.

A chart developed by shecco's public affairs department, presented by Masson, predicts that commercially available solutions using CO₂, ammonia, hydrocarbons, water and air as refrigerants will be available in nearly all European HVAC&R sectors in the period 2018-2020.

This trend was confirmed by the results of a shecco industry survey conducted in 2013 among European companies offering natural refrigerant solutions. Results showed that ammonia and CO₂ are mainstream solutions in the industrial heating and refrigeration sectors and are more commonly used by respondents than HCFCs and HFCs.

Japanese natural refrigerant technology market going from strong to stronger

Several suppliers confirmed similar positive market trends for Japan. For example, according to Kiyoshi Hishitani from Panasonic, natural refrigerant heat pumps and domestic refrigerators are now mainstream products in Japan.

"Change can happen very fast but ambition is needed. It is necessary to set clear policy frameworks to ensure investment security."

Nina Masson,
shecco

"The passion to use natural refrigerants is the most important element for us to be able to save our Earth for coming generations. We have to have the passion to promote and to use natural refrigerants. In Sanden's case, we have chosen CO₂."

Junya Ichikawa,
Sanden

Panasonic first introduced a CO₂ hot water heat pump back in 2001, followed in 2002 by a hydrocarbon compressor for domestic fridges. In 2004, commercial vending machine applications using hydrocarbons and CO₂ as refrigerants were introduced, and, most recently, Panasonic launched a CO₂ transcritical refrigeration unit for supermarkets and retail stores.

Gaku Shimada from Panasonic also said that, as of today, its CO₂ technology could be found in 145 locations across Japan, from Hokaido to Okinawa, in applications ranging from convenience stores (CVS) to hypermarkets and distribution centres.

The Japanese company Sanden has also played an active role in accelerating the market for CO₂ technology. According to Junya Ichikawa, Sanden has, until now, produced 300,000 units a year of its hermetic CO₂ compressor, used in commercial refrigeration units and heat pumps. However, in 2014 the production rate is being increased to between 600,000 and 800,000 units.

For industrial applications, Mayekawa, which provides natural refrigerant solutions using all five natural refrigerants, is also experiencing a growth in demand for its range of products. These include a CO₂ heat pump, an ammonia/CO₂ refrigeration unit called the NewTon, of which 500 units have already been installed around Japan, an adsorption chiller and an air cycle refrigeration system, of which 30 units are installed in Japanese cold storage facilities for tuna.

Adoption potential for natural refrigerants outside Japan and Europe

In other parts of the world, results of shecco's survey of largely Canadian and US HVAC&R firms indicates that North America has the potential to become a world leader in natural refrigerant technology, with a quarter of respondents saying they believe North America has a "high capacity" to become a world leader.

In developing countries, Masson said that natural refrigerants are mostly used in industrial refrigeration; however, they have a promising adoption potential in the domestic, commercial and light commercial refrigeration sectors.

SECTOR SPECIFIC TRENDS

CO₂ in commercial refrigeration

In the commercial refrigeration sector, end-users worldwide have started to adopt natural refrigerants on a large scale. According to Masson, there are over 3,080 CO₂ transcritical supermarkets and over 2,020 CO₂ cascade/secondary supermarkets across the world, and a minimum of 131 retail brands have invested in CO₂ commercial refrigeration.

"Looking at the cascade and CO₂ transcritical systems on this world map, we can really see that they are available on all continents. Europe right now is leading the adoption of CO₂ in commercial refrigeration, but other countries like Japan are quickly catching up."

Nina Masson,
shecco

In other parts of the world, results of shecco's survey of largely Canadian and US HVAC&R firms indicates that North America has the potential to become a world leader in natural refrigerant technology, with a quarter of respondents saying they believe North America has a "high capacity" to become a world leader.



In North America, the overall trend in the US is towards the installation of CO₂ cascade and secondary refrigeration systems. So far only four retailers have opted to trial CO₂ transcritical refrigeration, in addition to pharmaceutical giant Roche, which is working with Carel to install compact condensing units at its Indianapolis site for the cooling of pharmaceutical products. Masson estimates that there are at least 22 food retail brands investing in natural refrigerants in the US.

"We are going to notice a huge change in the next two years. We are at the tipping point, as we have seen in some of the presentations here, where a doubling in the number of systems has already been reported."

Ian Crookston,
Sobeys

"We would like to make natural refrigerants a standard. By the end of 2015, we plan to have 1500 natural refrigerant stores."

Shinichirou Uto,
Lawson

"We would like to move towards using CO₂ as a standard in stores, but one of the main hurdles has been cost. For this reason, support from the Japanese government is important."

Hiroaki Suzuki,
AEON

Canadian retailers, on the other hand, have chosen to invest in CO₂ transcritical refrigeration, with more than 65 CO₂ transcritical stores opened by Canadian retailer Sobeys alone. Explaining Sobeys' success in rolling out CO₂ TC in Québec, Ian Crookston from Sobeys said that one of the important factors supporting the uptake of this technology was that the retailer was very close to the suppliers, in addition to the fact that the installations were made in a market where government incentives were available. Most importantly, however, there was a commitment from the management.

In Japan, there is also a clear focus on transcritical solutions, with solutions for convenience stores at the focal point of research and development activities. Currently, there are 180 transcritical CO₂ stores in Japan, of which retailer AEON has 10 CO₂ stores, whilst Lawson already had 157 CO₂ TC stores by the end of 2013. Lawson is by far the leading natural refrigerant retailer in Japan. To maintain its industry leading position, in the fiscal year 2014, Lawson has planned to have 400 stores using CO₂ transcritical technology.

There are, however, issues that still need to be addressed to accelerate the uptake of CO₂ systems in Japan, including:

- **Training:** there are currently only a small number of technicians trained in CO₂. By the end of 2013, Panasonic had trained 372 technicians in CO₂ refrigeration.
- **Cost:** higher equipment and installation costs for CO₂ systems need to be reduced through increased production volumes and the use of high strength copper tubes.
- **Regulatory barriers:** several presenters at ATMOsphere Asia 2014 cited the High Pressure Gas Safety Act as a barrier.

In Europe, the number of transcritical CO₂ stores has more than doubled since shecco's first market survey in 2012. In her presentation, Masson drew particular attention to the fact that the success of CO₂ transcritical technology in countries like Denmark, Germany, Switzerland and Norway, all leaders in terms of number of installations, can be linked to their respective HFC taxes and fiscal incentives for HFC-free technology. Masson also highlighted Romania's newly opened CO₂ TC store, and Italy's plans for a further 10 CO₂ TC stores.

Other countries where the CO₂ commercial refrigeration market is showing signs of strong growth are:

- **Brazil:** the uptake of CO₂ commercial refrigeration systems in Brazil is proceeding at a fast pace with 40 cascade and secondary systems already installed
- **South Africa:** has 17 CO₂ TC systems installed by leading retailers Makro and Woolworths, which have achieved a reduction in power consumption of 45%

There is no shortage of components for CO₂ commercial refrigeration. ATMOsphere Asia 2014 saw both Alfa Laval's Rolf Christensen and Swep Japan's Peizhong Cong present their respective range of brazed plate heat exchangers for CO₂ transcritical applications.

Lastly, with regards to key technology trends, the two principle developments taking place in the CO₂ commercial refrigeration sector are: the development of solutions for warm climates and solutions for convenience stores, where space is at a premium.

Hydrocarbons in commercial refrigeration

In addition to CO₂, hydrocarbons are also making significant inroads in the commercial refrigeration sector on the European market. In Europe shecco has counted the following:

- **480,000 hydrocarbon plug-in units**, used, for example, by Lidl, which today purchases 60-70% of its low and medium temperature chest freezers using hydrocarbons as refrigerants.
- **285 indirect cooling systems**, used by supermarkets such as Waitrose in the UK, which has installed around 100 water-cooled hydrocarbon systems.

"They are happy with the system, because it is very easy to install and operate, is low maintenance, the temperature is maintained at a constant level, and the systems have a low failure rate, etc."

Bill Ho,
AHT Cooling Systems Asia Limited

"We do not think we are the only solution, but we think we are part of the solution."

Bill Ho,
AHT Cooling Systems Asia Limited

In North America, the business climate for hydrocarbon solutions has been less favourable than in Europe. However, large consumer goods brands are beginning to install hydrocarbon units in Canada, Mexico and the US.

Bill Ho from AHT Cooling Systems presented on the company's R290 cabinets. As hydrocarbons are, not yet, a widely known alternative for Japanese supermarkets, Ho's presentation aimed to communicate to the market that these systems are available and that this is a proven technology.

AHT Cooling Systems has supplied more than 530,000 of its R290 cabinets all over the world. In Asia, AHT has supplied 158 freezer cabinet units to a Korean supermarket. In Thailand SIAM MAKRO has been using AHT units since 2007 and has installed 2,750 cabinets.

HFC-free light commercial refrigeration

The use of natural refrigerants in the light commercial refrigeration sector is already a "success" story according to Masson, with over 2.7 million HFC-free units worldwide. Two thirds of respondents to a shecco survey of companies offering solutions for light commercial refrigeration applications stated that natural refrigerants represent the leading technology. Furthermore, 35% of survey respondents believe the market share of hydrocarbons will be over 21% by 2020.

Large consumer goods brands such as The Coca-Cola Company, which has 1 million HFC-free units, and Red Bull, which has around 500,000 hydrocarbon coolers, are driving this change. Nevertheless, there remains a large untapped potential in this market.

Looking specifically at the situation in Japan, Yoshinari Okuyama from The Coca-Cola Company, talked about his company's involvement in the "Refrigerants, Naturally!" initiative and its commitment to replace fluorinated gases in refrigeration equipment with climate-friendly natural refrigerants. Okuyama said that all new vending machines purchased in Japan are now HFC-free, thanks to the support of suppliers Panasonic and Sanden. The Coca-Cola Company is also continuing its efforts to expand HFC-free solutions to its coolers and dispensers and smaller size equipment.

Despite sales dip, Eco Cute remains leading CO₂ technology in Japan

According to Naruhide Kimura from Denso, since the 2011 earthquake, heat pump sales, which reached a cumulative peak of 4 million units, have started to decline. However, the inclusion of heat pump water heaters in the Japanese Top Runner Approach in 2013 could reverse this negative trend.

"There is a production capacity of over half a million units a year, so it [Eco Cute] is actually a mass product."

Marc Chasserot,
ATMOsphere Asia 2014 Chairman,
shecco

Innovation within the Eco Cute sector continues to progress. In the residential sector, Denso has developed a multi-functional CO₂ heat pump that also supports space heating and in the commercial sector, Mitsubishi Heavy Industries (MHI) has developed a CO₂ heat pump that is efficient at -25°C.

Junya Ichikawa from Sanden said he is unsure how the European market for domestic CO₂ heat pumps for hot water and space heating will develop.

In the industrial refrigeration sector, ammonia/CO₂ gains ground

According to shecco, in the European industrial refrigeration market, 90% of large installations use ammonia. For the coming decade, NH₃ is forecast to maintain its position as a mainstream solution. Whilst the European Commission expects 55% of new industrial systems to use ammonia, results from shecco's most recent European industry survey show that ammonia will defend its market leading position in the next 7 years. Carbon dioxide will likely gain a greater market share, in particular when used in combination with NH₃. The market share of hydrocarbons in industrial refrigeration is expected to remain relatively small, largely confined to the petrochemical sector and other specialised applications.

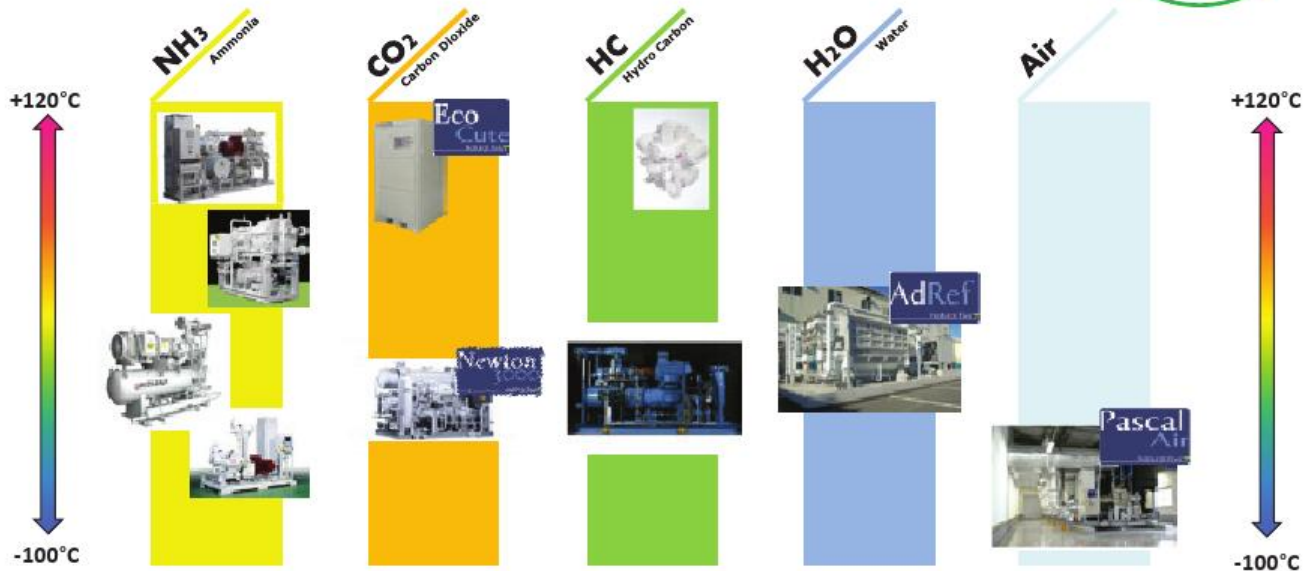
In the US, a country that consumes one of the highest levels of frozen foods in the world, ammonia refrigeration plants represent the backbone of the food processing and storage industry. The results of shecco's North American industry survey suggest that NH₃'s market dominance will continue at least until 2020.

In her presentation, Masson explained that there are different drivers behind the uptake of natural refrigerants in the global industrial refrigeration market. Whilst legislative pressure in Europe will further drive the move towards low-GWP and mostly natural refrigerant solutions, in the US, cost is expected to be the most important driver of future technology trends.

On behalf of Danfoss, Youichi Saito from Saginomiya confirmed that ammonia still ranks number one as the refrigerant of choice in medium and large sized industrial refrigeration plants. However, there is an increased focus on NH₃/CO₂ secondary and cascade systems in Japan, North America and Europe. In Japan, CO₂ is starting to make significant inroads as a secondary refrigerant in industrial refrigeration systems, both in cold storage and food processing facilities. This was also evident in figures presented by Mayekawa, regarding the number of NH₃/CO₂ NewTon system installations around Japan, which stands at almost 500.

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natural refrigerant case studies



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Alfa Laval

The Technology Case Study presentations at ATMOsphere Asia 2014 featured case studies from around the world that showed best practice in the use of natural refrigerants for a range of applications, from commercial and industrial refrigeration to commercial air conditioning and heating.



natural refrigerant case studies

CO₂ transcritical commercial refrigeration case studies

Japan: For Japan, Gaku Shimada from Panasonic presented the following measured annual energy savings for a range of Panasonic's CO₂ refrigeration installations:

- CVS store in Miyagi: 26% increase in energy savings over conventional R404a system
- CVS store in Okinawa: 10% energy savings are achieved – largely due to the very hot summer
- Supermarket in Chiba: 21% energy savings are achieved
- Supermarket Aichi: 19% energy savings are achieved

Norway: In Trondheim, Norway, Sintef and Danfoss have collaborated to provide retailer REMA 1000 with CO₂ solution for floor heating, ventilation, air-conditioning, snow melting and storage of thermal energy. The system combines refrigeration and heat pump functions, and expected energy savings from the system are predicted to reach 30%.

Spain: A case study presented by Nina Masson drew attention to a CO₂ transcritical installation in Spain, which has a warm climate. The Carrier installation is in a Carrefour supermarket, and features a roof-top mounted subcooler. The system has been operating successfully for one year and has an energy consumption equivalent to existing HFC systems installed in Southern Climates.

Sweden: At a Coop store in Tockfros, Sweden, Advansor supplied a CO₂ system that meets the supermarket's refrigeration, AC and heat recovery needs. The system combines parallel compression and is expected to achieve 6.3% energy savings for refrigeration.

UK: In the UK, Sainsbury's has installed a small footprint Epta refrigeration system at the Haslucks Green store in Solihull. Promoted as the UK's most environmentally friendly convenience store, the CO₂ refrigeration system has helped to reduce carbon emissions by 33% and minimised the energy uses for cooling.

CO₂ heat pump case studies

China: In China, three 50 kW heat pumps have been installed at the Bumade station on the Qinghai Tibet railway line at an elevation of 4,800m above sea level. The CO₂ heat pump is used for space and water heating and is able to operate efficiently at outside temperatures as low as -30°C.

Also in China, a CO₂ heat pump was combined with an electric boiler for hot drinking water production at Wuhan University. The hybrid system is able to produce 5 tons of hot drinking water a day and has helped to achieve 50% energy savings.

Taiwan: Nihon Itomic's Eco Cute installations include a Taiwanese leather-processing factory, where the heat pump ensures a constant supply of high temperature hot water (90°C) with a stable COP whilst reducing the operating costs of the steam boilers. The payback of such an installation is estimated to be about 2-3 years. Other installations can be found in Northern Japan.

Japan: Examples of Mitsubishi Heavy Industries (MHI) Q-Ton installations can be found in the Japanese hot spring inn in Matsumoto and Kanazawa, where the Q-Ton was combined with the existing boiler and tank system and used to supply hot water. Featuring a two-stage CO₂ compressor MHI's CO₂ heat pump water heater maintains 30kW capacity in temperatures as low as -7°C. Other installations can be found in schools and food factories that require large amounts of hot water for cleaning.

Nihon Itomic's commercial CO₂ heat pump was installed in a Northern Japanese nursing home where, despite harsh weather conditions in the winter, the system's COP has remained relatively unchanged compared with conventional heat pumps. The storage tanks are specifically designed to insulate from the severe winter conditions and equipped with a heating wire. A heater is automatically switched on when the ambient temperature goes down lower than the preset one.

Sweden: In Sweden, Alfa Laval was involved in a CO₂ transcritical heat pump project in Lund. To provide domestic hot water and heating for 24 apartment buildings with more than 400 apartments, two different capacity heat pump units were developed: 54 kW and 68 kW. The system features two storage tanks, a high temperature hot water tank (65°C), which also provides hot water for the radiators, and a low temperature water tank (38°C) used to cool down the CO₂ condensate. By combining hot tap water and radiator hot water, it is possible to lower the return temperature from the radiators, helping to reduce energy consumption. The heat recovery unit is located on the roof and takes in all the air from the apartments in a common exhaust duct. Total annual energy savings for this project are calculated at about €1.1 million, and the pay back period is expected to be around 5 years.

Hydrocarbons commercial refrigeration case study

Thailand: According to Bill Ho's presentation, AHT cabinets have been successfully installed at a SIAM MAKRO store in Thailand. The key features of the installations are as follows:

- Significant electricity savings
- Product temperature maintained -18° to -22°C
- No AC during the night time
- Very low failure-rate and no maintenance

NH₃/CO₂ industrial refrigeration case studies

Japan: One of the largest cold stores in Japan, the 200,000m³ cold storage facility in Kawasaki features 11 NewTon NH₃/CO₂ packages for -25°C frozen food and loading rooms, according to Hideyo Asano from Mayekawa. Compared to NH₃/brine and HCFC-22 systems, the NewTon NH₃/CO₂ system consumes, on average, less energy, and the Kawasaki cold store is the most efficient in Japan.

Katsuyoshi Nihei from the CO-OP presented on the CO-OP TOSU cold distribution centre, which opened in 2009 and uses one of the latest freezing systems based on NH₃/CO₂. Only a small quantity of NH₃ is charged, addressing safety concerns, whilst CO₂ heat pumps are used to provide space heating. Nihei also discussed the CO-OP's Onomichi cold logistics centre, built in 2012, which uses 6 units of NH₃/CO₂ systems and 4 CO₂ heat pumps. The project was awarded the "2012 Japan Prestressed Concrete Institute Award."

Indonesia: With the funding support of the Japanese Ministry of Environment (MOE) under the Joint Crediting Mechanism (JCM), the first NewTon installation in Indonesia will be completed in a cold store operated by P.T. ADIB Global Food Supplies in March 2014. The expected reduction in annual energy consumption is 570,000 kWh.

China: On behalf of Danfoss, Youichi Saito from Saginomiya presented a Danfoss case study of a NH₃/CO₂ demonstration project at Weihai Jiuye Cold Storage Co. Ltd. in China's Shandong province. Compared to the original system, which had an efficiency of 118 kWh/Ton, the NH₃/CO₂ system achieves an energy saving of 11%. The NH₃ charge is reduced to 1/10th that of traditional systems, a key feature that addresses safety concerns and allows for the construction of large plants in heavily populated areas. Saito believes NH₃/CO₂ refrigeration technology is starting to make significant inroads in industrial refrigeration systems in cold storage and food processing facilities in more and more Asian markets. The project has the following features:

- Temp in: 10°C
- Temp out: -18°C
- Duration: 30mins
- Efficiency: 105 kWh/Ton

Also in China the Zhangzi seafood processing plant uses a cascade refrigeration system and CO₂ brine system for cold storage, lowering the refrigeration plant's ammonia charge by 90%.

NH₃ industrial refrigeration

Australia: Involved in over 800 NH₃ projects over the past 45 years, Klass Visser of KAV Consulting was asked to provide a solution to double the cooling capacity of a refrigerated fruit warehouse, used to store and cold sterilise products at 1°C to prevent fruit flies. The required refrigeration capacity increase was 110-190 kWR, depending on the fruit's temperature. The maximum power supply capacity increase allowed was 9.5%.

The solution Visser developed involved replacing the original R22 system with an ammonia-glycol refrigeration system, doubling the cooling capacity whilst not increasing the energy consumption.

The increase in connected load was 22-27%, and the system was initially built with some of the following features:

- Propylene glycol circulating pump
- High-efficiency PGC pump to reduce electrical energy consumption
- Min 2 ammonia compressors
- VSDs fitted to all compressors
- New evaporative condenser fan & pump
- ECM motors specified to drive fans on the new glycol coolers

Overall, the ammonia-glycol system only increased the maximum demand (MD) by 16% kW or 4.2%, which was achieved for a refrigeration capacity increase of 60%.

Absorption refrigeration case studies

Japan: A Kawasaki absorption chiller was installed in the Shiga Factory, where it is combined with a solar collector (evacuated tube type) installed on the factory rooftop. This system provides cooling and heating to the office. Hajime Yabase's presentation provided the following evaluation of the system installation:

- On a spring day (20 May) – at a max temperature of 28.4°C the AC loading factor was 23%. Hot water obtained from the solar energy collector was used at 60-83°C. The system enabled the gas amount to be reduced by 25%.
- In mid summer (28 July) - at the max temperature of 34.5°C, the AC loading factor was 60%. The hot water obtained from the solar energy collector was used at 60-75°C. The system enabled the gas amount to be reduced by 11%.

Indonesia: The Ministry of Environment of Japan sponsored a solar cooling air conditioning system featuring a Kawasaki absorption chiller installation at the University of Indonesia (further details are discussed in the New Technologies and Research Chapter).

Adsorption refrigeration case studies

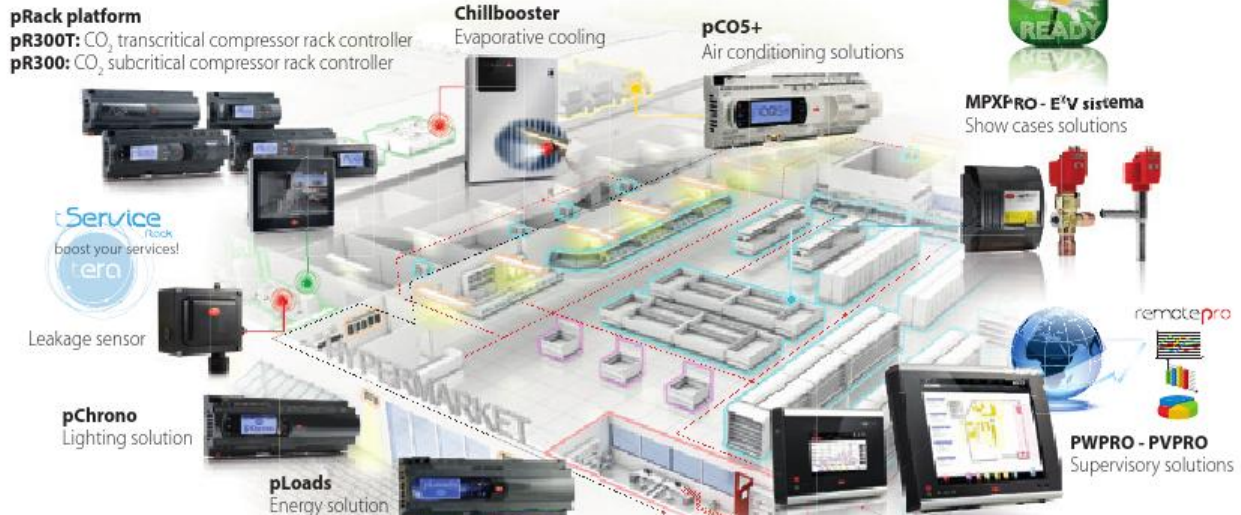
Japan: Nowadays, more and more Asian countries are introducing adsorption chiller technology to provide heating and cooling for commercial buildings and industrial processing. For example, the CO-OP has decided to install an adsorption chiller at its new 7,437m² office building (the second CO-OP Plaza building) in Shibuya-ku, Tokyo, an ongoing project that is planned for completion by February 2015.

Natural refrigerant case studies from around the world

- **Brazil:** first R600a water fountain commercially available
- **China:** R290 room A/C mass production possible
- **Cuba:** successful market uptake of HC blend developed in the country
- **India:** 3,000+ R290 A/C units sold by 2012 - well suited to high temperatures
- **Indonesia:** commercial A/C/ and refrigeration systems with R290 for 15% energy savings
- **Pakistan:** 5,000 R290 bottle coolers sold; 15,000 new R600a domestic refrigerators
- **Thailand:** retrofit of industrial A/C with HC blends achieve 20% energy savings
- **Zimbabwe, Angola, Tunisia:** "plug-and-play" ammonia chillers achieve carbon footprint reduction of 12 tonnes CO₂/year, compared to R134a

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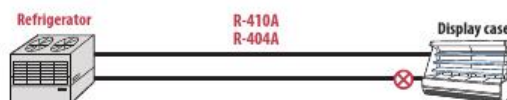
Main business :

- Design and installation for air-conditioning and refrigeration facilities
- Development and operation of thermal storage system

The proposal on low-HCFC and/or HCFC-free for R-22 system

R-22 : Its available supplies in the market will be significantly reduced since 2015 and then its "unavailability" and "price increase" are concerned about.

Present approach : Replace R-22 for refrigerator to R-410A, R-404A



Ozone layer protection: Global warming prevention:

The availability of refrigerants is increased, however, it influences greater on the global warming. It's concerned about that the emission of greenhouse gases will reach 40 million ton CO₂/year, and the governments feel sense of danger.

Proposal approach : Replace R-22 for only thermal storage refrigerator to R-410A, R-404A
STEP-1



Ozone layer protection: Global warming prevention:

Replace to Ultra Eco-Ice System which uses brine-ice, while the display case is leaved as is.
It could recover the initial cost within 5 years to install thermal storage system which uses nighttime electric power.

Proposal approach : Replace R-410A, 404A for only thermal storage refrigerator to CO₂ (NH₃)
STEP-2



Ozone layer protection: Global warming prevention:

For low-HCFC, replace the area between refrigerator and the storage tank (outdoor) to HCFC-free system if CO₂ (NH₃) refrigerator will be available in the future.

Ultra Eco-Ice system

PAJ No.3853965 PAJ No.3856572 PAJ No.3742043

new technologies & research



GAKU SHIMADA

Panasonic Corporation
(Session Chair)



MICHAEL ENGLEBRIGHT

Carel (Session Chair)



PEGA HRNJAK

University of Illinois



KIYOSHI SAITO

Waseda University, Tokyo



YUKIO YAMAGUCHI

Sanden



SADAO NISHIMURA

YAMATO



KATSUHIKO HARADA

Nihon Netsugen Systems



FUJIO KOMATSU

Mayekawa Manufacturing



HIROSHI TAKIGAWA

Mitsubishi Heavy Industries



KAZUYUKI OCHIAI

Nihon Itomic



NARUhide KIMURA

Denso

ATMOsphere Asia 2014 provided a showcase for some of the most advanced natural refrigerant technologies developed by Japanese and European companies. In addition to presentations on new natural refrigerant research projects, many concrete examples of state-of-the-art solutions illustrated the event's tagline "Technology and Innovation." These included the latest CO₂ transcritical solutions for supermarkets and convenience stores, commercial and residential CO₂ heat pump innovations, industrial NH₃/CO₂ refrigeration packages, absorption and adsorption refrigeration chillers and air cycle refrigeration plants.



new technologies & research

"In vapour compression systems, hydrocarbons, carbon dioxide and ammonia have the serious potential to become a mainstream option in refrigeration, air conditioning and heating."

Pega Hrnjak,
University of Illinois

"Japan has always been a technology leader in natural refrigerants. Last week we were able to get a glimpse of new trends with regards to commercial refrigeration at HVAC&R Japan. We saw many new companies offering new solutions to the supermarket segment here in Japan. When you combine that with legislation and new funding programmes developed by METI and MOE, you can expect this trend to grow."

Marc Chasserot,
ATMOsphere Asia 2014 Chairman,
shecco

"If CO₂ would be accepted in mobile applications, the maturity of CO₂ technology would develop, prices would go down, and all of that will spread to all other applications, so we will see dramatically better products at lower costs."

Pega Hrnjak,
University of Illinois

Natural refrigerant research continues to gather momentum

In the opening presentation of ATMOsphere Asia 2014, Pega Hrnjak from the University of Illinois presented an overview of some of the very latest research into natural refrigerant technologies, three of which he believes have the serious potential to become mainstream options for HVAC&R applications.

Speaking specifically about Japan, Professor Saito from Waseda University said it has one of the most advanced markets for natural refrigerant technologies. Whilst CO₂ transcritical heat pump technology developed and commercialised over a decade ago, and absorption chillers over 40 years ago, today, some of the most cutting-edge natural refrigerant technology, such as air cycle refrigeration systems and centrifugal chillers using water as the refrigerant, are being manufactured in Japan.

One of the most dynamic fields of research is in the use of CO₂ as a refrigerant. Current research in this field includes a CO₂ heat transportation system for cooling hot spots in data centres, which is being researched at Waseda University in Tokyo, and CO₂ in the commercial refrigeration sector. For supermarkets and convenience stores, the know-how accrued in the development of CO₂ transcritical water heaters is being applied.

With regards to CO₂, Hrnjak drew attention to research into the use of R744 in mobile air conditioning (MAC) systems, which he explained does not have low efficiency. Leading OEM Daimler has, in fact, decided to develop CO₂ MAC for its vehicle fleet.

Research into hydrocarbons and ammonia as refrigerants is also continuing, with particular interest in the use of hydrocarbons in mini split air conditioners in China and into reducing ammonia charges.

Future Japanese research on the topic of natural refrigerants will include the development of a natural refrigerant map showing the most suitable application for each refrigerant, analysing its performance, safety and costs to help identify the most suitable refrigerants for different countries.

Small footprint CO₂ commercial refrigeration systems for convenience stores

Within the area of CO₂ commercial refrigeration research, the development of systems for small format stores is of particular interest, given the rapid evolution of the convenience store (CVS) market and the revised fluorinated refrigerants regulations in both Europe and Japan.

Carel's Michael Englebright explained that Japan has a lot of experience in small forecourts and convenience stores (CVS), unlike Europe where larger supermarket format stores have traditionally been standard.

Panasonic first launched a CO₂ commercial refrigeration system for CVS in 2010, which was installed by retailers Lawson and AEON. According to Kiyoshi Hishitani's presentation, compared to an R404A system, Panasonic's CO₂ system is 25% more efficient for low temperature freezers and 16% more efficient for mid-temperature refrigerators. Overall, the system achieves a 60% reduction in CO₂ emissions, compared to an R404A inverter unit.

Panasonic's Gaku Shimada provided further details about the components in the company's complete small format CO₂ commercial refrigeration system:

- **Cooling module:** 2HP and 10HP outdoor condensing units consisting of a two-stage rotary CO₂ compressor and split cycle technology with split internal heat exchanger and intercooler
- **CO₂ compressor:** the split cycle 2HP compressor has two-stage compression and an economizer to increase the system efficiency
- **Master Controller**

Sanden has also developed a CO₂ solution for CVS, as presented by Yukio Yamaguchi. The cascade system with a cooling capacity of 2 – 9 kW has the following components:

- **Cooling module:** multi-compressor system and all aluminium gas cooler
- **CO₂ compressors:** high efficiency, low noise and vibration, high reliability
- **Multi control system:** to control the cooling modules and showcases

Thanks to the smaller diameter copper tubing that is used, the CO₂ system has reduced material costs, and achieved an average of 29% energy savings in tests, compared to a conventional HFC system.

In addition to these systems, Carel has developed a high pressure proportional stepper valve specifically targeting the CVS market.

CO₂ systems for warm climates

The second key research area in commercial CO₂ refrigeration is the development of transcritical systems for warmer climates. Using a split cycle system, manufacturer Panasonic and Japanese retailer Lawson are already reporting energy savings of between 10-21% for a CO₂ transcritical system in the subtropical region of Okinawa, Japan (compared to equivalent equipment based on the conventional refrigerant R404A).

With the annual power consumption of the CO₂ system measuring at 63,801 kWh (compared to 80,605 kWh of the R404A system), the energy savings translate into an annual cut of ¥235,256 (around €1,708) on the energy bill. Despite operating in subtropical ambient temperatures, the system's annual energy savings are only slightly lower than the national average, measured at 27%, further encouraging the optimisation and deployment of CO₂ systems in the warm and humid climates of Asia.

"We can learn from European cases, but our responsibility is to develop a CO₂ system that matches the hot and humid climate of Asia."

Gaku Shimada,
Panasonic

Panasonic's Shimada said Japanese companies have an important role to play in the development of systems that can accommodate specific conditions in the Asian region.

Shinichirou Uto, who heads the Construction Planning Department at Lawson, shared results of the trial CO₂ transcritical installations in subtropical Okinawa. He also announced that, with the support of the Japanese Ministry of Economy, Trade and Industry (METI), the retailer would open the first pilot CO₂ transcritical store in Peta Barat in Jakarta, Indonesia, on 7 February 2014. This store will provide the retailer with a lot of useful experience and data on the energy consumption of CO₂ systems in tropical climates. Uto pointed out that the introduction of CO₂ in warmer climates by Lawson and other retailers could provide a double-dividend, bringing the costs down while being friendly to the environment at the same time.

A simulation performed by Lawson shows energy savings of 39% with CO₂ systems in tropical Indonesia, compared to the current R22 technology.

Japanese CO₂ booster system and Ultra Eco-Ice (UEI) for medium and large supermarkets

Japanese companies are also innovating when it comes to commercial CO₂ solutions for larger format stores. Katsuhiko Harada from Nihon Netsugen Systems presented a prototype CO₂ transcritical booster system consisting of transcritical and subcritical compressors. The advantage of this system is that one unit can cool both medium temperature and low temperature cabinets, whilst creating hot water by way of heat recovery.

In partnership with cabinet maker Fukushima Industries, Nihon Netsugen Systems began testing such a system in 2013 to verify the COP, cooling speed, operation under hot summer conditions, the heat recovery function and the CO₂ safety devices at the Fukushima factory. The first supermarket installation is planned for 2014, but before then, Nihon Netsugen Systems will investigate how to improve the system's summer COP, testing the cabinet performance in up to 40°C temperatures.

Sadao Nishimura from Yamato presented on the company's innovative Ultra-Eco-Ice (UEI) System, which is now used in 13 different facilities. The patented Ultra Eco Ice system is a next generation refrigeration system which uses cold energy accumulated during nighttime for refrigeration & air conditioning inside the store and display cases: during nighttime, thermal storage refrigerators produce low-temperature brine ice (-6°C) that is accumulated in a thermal storage tank. By storing thermal energy over night, the UEI system allows supermarkets to better deal with peak demand during the day. Moreover, in winter the system recycles the condensing heat recovered from the refrigerators in-store floor heating.

Latest developments in CO₂ vending machine sector

In the light commercial refrigeration sector, the market for CO₂ vending machines is also developing apace, thanks to the decision by leading soft drinks manufacturer The Coca-Cola Company to purchase only CO₂ units, including the Peakshift Vending Machine, one of the most advanced CO₂ vending machines. Awarded the Energy Conservation Grand Prize by the Ministry of Economy, Trade and Industry (METI), the CO₂ vending machine shifts energy consumption from daytime to nighttime.

Eco Cute continues reign as leading Japanese CO₂ technology thanks to new innovations

ATMOsphere Asia 2014 was also a platform for presentations on the latest CO₂ heat pump (Eco Cute) technologies available for commercial and residential applications, including Mayekawa's Unimo, Denso's solar hybrid model, Itomic's commercial Eco Cute models, as well as the Q-Ton from Mitsubishi Heavy Industries.

For the residential Eco Cute sector, Naruhide Kimura from Denso Corporation presented the company's series of CO₂ heat pump units that cover a wide range of household sizes and regions, ranging in capacity from 4.5kW to 7.0kW. Most recently, Denso has developed a multi-functional model with combined floor heating, and a solar hybrid model, developed in conjunction with Sharp. The latter features:

- Integrated controller for PV system and Eco Cute
- "Solar power assist" function that enables operation of Eco Cute with stored energy prior to solar power generation in the morning
- "Summer mode" function allows for daytime savings without the concern of running out of hot water

Another solar heat collector hybrid model with an Annual Performance Factor of 5.0, has been available since 2010 and is a result of Denso's cooperation with Yazaki.

Fujio Komatsu presented Mayekawa's Eco Cute 'Unimo', an air and water source CO₂ heat pump suitable for industrial and commercial installations in hospitals, hotels, sport and other facilities. The system can achieve a 62% reduction in CO₂ emissions compared to conventional hot water boilers. Designed to provide a constant supply of hot water, the output temperatures reach up to 90°C.

Komatsu's presentation also highlighted Mayekawa's CO₂ hot air heat pump, the 'Eco Sirocco,' which can achieve close to a 50% emissions reduction compared to conventional systems. Suitable for material drying and heating, paint drying and similar applications, the heat pump provides a high level of safety and avoids the risk of possible damage due to combustion.

Hiroshi Takigawa, Sales Manager at Mitsubishi Heavy Industries (MHI) Air Conditioning & Refrigeration System Solutions Division, introduced the company's new CO₂ heat pump, the Q-Ton. With a rated heating capacity of 30kW, which is maintained in ambient air temperatures as low as -7°C, the air source heat pump is probably the first to use a two-stage CO₂ compressor. The scroll and rotary compressor was developed to avoid the significant reduction in heating capacity that occurs in low ambient temperatures. The average COP of the heat pump is measured at 3.04.

Field-testing in severe winter conditions in Hokkaido with temperatures as low as -20°C proved the performance of the Q-Ton, while reducing energy costs to 43-54% compared to conventional boilers. Takigawa pointed out that in intermediary and summer seasons, the heat pump's performance improves, further decreasing energy costs. As a result, annual running costs can be cut by 61% with an overall 29% CO₂ emissions reduction compared to a conventional boiler.

"CO₂ has proven to be highly efficient, low GWP and energy saving."

Kazuyuki Ochiai,
Nihon Itomic

Nihon Itomic's expertise in developing Eco Cute products for a decade now, was presented by Kazuyuki Ochiai. The company's optimised Eco Cute line up includes:

- Small sized Eco cute with a Panasonic compressor (9kW/12kW)
- Medium sized Eco Cute with a Dorin compressor (26kW/30kW)
- Large Eco Cute with an inverter and a Bitzer compressor (50/80kW)

Latest brazed plate heat exchanger technology for CO₂ transcritical applications

SWEP Japan's Peizhong Cong presented on the development of the company's CO₂ transcritical brazed plate heat exchanger (BPHE) technology. Gas cooler analysis revealed that CO₂ has a larger pinch temperature difference, needs a larger heat transfer area and is not sensitive to pressure drop. Taking this into account, SWEP developed AsyMatrix BPHE, which uses a tailored pattern of narrow and wide channels as opposed to a symmetric pattern. This design results in improved heat transfer, lower pressure loss, reduced dimension and improved mechanical strength.

Latest developments in hydrocarbon refrigeration and AC technologies

Hydrocarbon research and the newest technology developments, were featured in presentations by Professor Pega Hrnjak from the University of Illinois, Professor Kiyoshi Saito from Waseda University, and Bill Ho from AHT Cooling Systems.

According to Hrnjak, hydrocarbons R290 and R600a, whose flammability can be mitigated by design, are almost a drop-in replacement of R22 and R12 or R134a, respectively. To date, the most successful application of hydrocarbons has been in domestic refrigerators, but their use is also growing in bottle coolers, self-contained cabinets and in supermarket racks, where they are used as secondary fluids or in cascades.

Kiyoshi Saito from Waseda University in Tokyo presented one of the newest hydrocarbon technologies, a hydrocarbon ejector solar cooling system, which uses ejectors and generators instead of compressors. Since the ejector is a very small device, the total size of the system can be reduced. The system is driven by solar energy.

Professor Saito also presented a simulation involving the use of an R410a air-conditioning system with hydrocarbon drop-in, calculating the performance of the system using R410a and R600a. He found that R600a is a very good refrigerant with an average COP that is 10% higher than R410a. However, the experiments following the theoretical calculation showed that while the COP for drop-in R600a is approximately the same as for R410a, the cooling capacity decreases greatly. Therefore, he concluded that R600a performs best when used in systems designed for hydrocarbons and not as a drop-in solution, which could also have safety implications. Current research is focused on optimising the air-conditioner with R600a through simulations.

In the commercial refrigeration sector, AHT Cooling Systems manufactures some of the most advanced R290 cabinets for supermarkets and convenience stores. The stand-alone cabinets can be banked together in an isle and can lead to significant energy savings compared to remote systems. Thanks to a series of innovations, the R290 cabinets can achieve a 50% reduction in energy consumption in kWh over a 24-hour period.

Latest ammonia research includes charge reduction and NH₃/CO₂ refrigeration packages

Charge reduction is the focus of research into ammonia as a refrigerant. One solution, presented by Pega Hrnjak, is to reduce the internal volume and avoid an increase pressure drop by changing the flow regime. He explained that the key is to increase the vapour volume fraction, or so called void fracture, which, in other words, is how much volume is occupied by the vapour compared to total volume. More vapour means less liquid and lower charge.

Research into ammonia charge reduction has also led to an increasing number of R717/R744 cascade solutions being implemented in commercial and industrial applications. Hideyo Asano from Mayekawa presented on one such product, the NewTon NH₃/CO₂ with ammonia as the primary refrigerant and CO₂ as the secondary refrigerant. CO₂, selected after various other liquids were assessed, was evaluated as the best secondary refrigerant for this solution.

The NewTon consists of an NH₃ semi-hermetic compressor with a high-efficiency IPM (Internal Permanent Magnet) motor, proven to be 5-10% more efficient than an induction motor. A new rotor profile was integrated into the system, in addition to a new plate heat exchanger. The package also includes a liquid CO₂ tank and pump. The NewTon is suitable for 20,000 m³ to 200,000 m³ facilities.

In March 2014, the first NewTon installation will be completed in Indonesia in a cold store operated by P.T. ADIB Global Food Supplies.

High efficiency water refrigeration technologies

Hajime Yabase from Kawasaki Thermal Engineering presented on his company's innovative solar air conditioning system developed using a single-double effect combined absorption chiller. The system is powered using solar thermal energy, which has an efficiency of 40%, higher than that of photovoltaic energy, which is only 10%.

The key features of this system are that it is a freon-free air conditioning machine using water as the refrigerant, it consumes much less power than electric chillers, and various energy sources can be utilised (rest heat, every kind of thermal energy). Moreover, unlike the previous complex absorption system that relied on a back-up boiler and had a complicated control system (to adjust the hot water supply in accordance with the fluctuation of load and solar heat), Kawasaki's absorption chiller is automatically moved to combustion for the stable supply of chilled water.

Kawasaki's solar absorption chiller was installed at the University of Indonesia, where performance tests have shown that at a capacity of 281 kW, the chiller has an electricity consumption of 2.25kW, which is much lower than the 70.25kW of energy consumed by an electric chiller at the same capacity. The double effect absorption chiller is also estimated to reduce CO₂ emissions by 57% compared to electric chillers.

Also using water as a refrigerant is the adsorption chiller, which was presented by Fujio Komatsu from Mayekawa. The company's "AdRef Noa" uses water as a refrigerant and zeolite as the adsorbent to produce cool water from a low-temperature heat source (below 75°C). This system, which has a cooling capacity of 100kW – 400kW, can achieve a 64% reduction in CO₂ emissions compared to traditional systems. In a case study highlighting a 100USRT industrial process cooling facility with a cold water temperature of 9°C, the adsorption chiller consumed 36kW, whereas an R134a cooling system used 100 kW.

"With the applications for natural refrigerants expanding, which is logical, three dominant fields of applications are heat pump water heaters, refrigerators with isobutene and ammonia with industrial refrigeration. Supermarkets, small commercial units are on a good trajectory to become mainstream. Mobile air conditioning is back to the proving arena, so we are still looking into what will happen. When treated with understanding, each of these main alternatives is excellent and could be very competitive based on efficiency."

Pega Hrnjak,
University of Illinois

Air cycle refrigeration technology

In conjunction with NEDO, Mayekawa has also developed an air cycle refrigeration system called the "Pascal Air" for low temperature applications ranging from -50 to -100°C. The system is ideally suited for cold tuna storage, which requires temperatures of -60°C. According to the presentation by Kuniaki Kawamura from Mayekawa, the turbo compressor with integrated expander allows for the achievement of a high COP and energy savings of up to 50% compared to conventional refrigeration systems. Furthermore, the dehumidifying agent reduces frosting in storage and, therefore, defrosting is not required. Kawamura said that compared to a conventional R22 two-stage compression refrigerator, which uses 281 kW, the Pascal Air only uses 128 kW.



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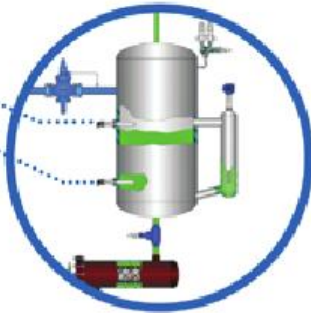


Sensors for natural refrigerants - CO₂ & NH₃

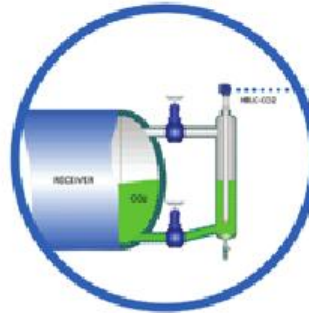
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High/low alarm



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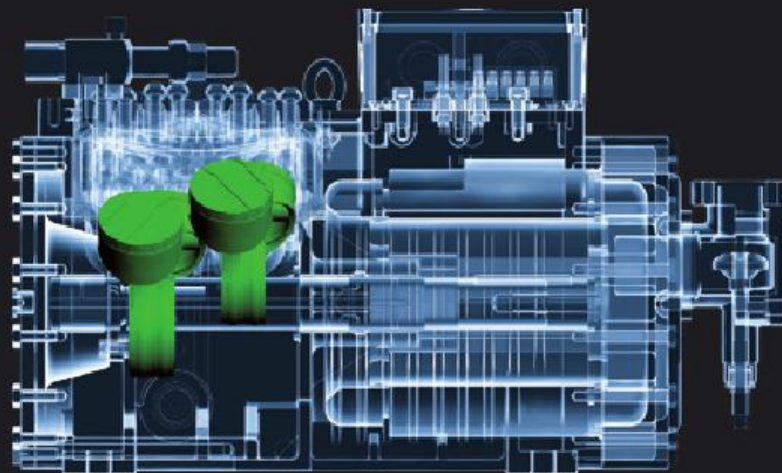
Applications

- On/Off control of refrigerant liquid level
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- Analogue level sensing of liquid CO₂

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OCTAGON CO₂

CO₂ AS A REFRIGERANT?
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reception at the Belgian Embassy in Japan



Technological innovation links Japan and Belgium

ATMOsphere Asia 2014 featured an exclusive networking reception at the Embassy of Belgium in Japan with dinner speeches by the Deputy Ambassador and the President of Panasonic ES Commercial Equipment Systems.

"Knowledge and creativity are our main assets. We need to develop new technologies, new ways to work, and new ways to live and interact with each other. Innovation is crucial for the future of our societies and of our businesses. Only companies that invest in research, that prepare for the future, can hope to have a future," said Christophe de Bassompierre, his Excellence the Deputy Ambassador to the Embassy of Belgium in Japan.

"In 2020, the production of R22 is planned to be terminated. By that time, I believe that Japan will have seen a wider spread of natural refrigerants," noted Yasuhiro Shibata, President at Panasonic ES Commercial Equipment Systems. "Environmental measures have to be promoted with everyone concerned working closely together. Panasonic is determined to take the lead in product development in the area of natural refrigerants in Asia and Japan," Shibata added.



High-efficient chillers for air conditioning and industrial
 BluAstrum offers a long-lasting and sustainable solution using the natural refrigerant R717. The series fulfils the highest expectations for meeting cooling and refrigerant requirements in the temperature range from -15 °C to 15 °C.



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ATMOsphere business case natural refrigerants

June 2014, San Francisco



THE BUSINESS CASE FOR NATURAL REFRIGERANTS IN NORTH AMERICA

The meeting place for industry experts to discuss natural refrigerant trends, the latest technologies and regulatory issues in North America is back for its **third edition!**

Taking place for the first time in **San Francisco in June 2014**, this event targets around 200 decision makers including leading retailers, suppliers, associations and more.

Presentation topics will focus on **regulation, standards and utilities**, as well as on **commercial and industrial refrigeration** applications with input from key government representatives, **end users** (retailers, consumer brands, cold storage) as well as technology **providers**.

New features for the 2014 edition include more networking opportunities, optional site visits (tbc) and several new technology case study sessions on heat pumps and HVAC.



June 2014

www.ATMO.org/America2014

Upcoming ATMOSphere Event



ATMOsphere Europe 2015 - Solutions for Europe
 March 2015, Brussels, Belgium

More information about this event and other ATMOSphere events coming soon.

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glossary

CO₂ – Carbon dioxide
COP – Coefficient of Performance
EU – European Union
HC – Hydrocarbons
GWP – Global Warming Potential
HCFC – Hydrochlorofluorocarbon
HFC – Hydrofluorocarbons
HVAC&R – Heating, Ventilation, Air conditioning & Refrigeration
JRAIA – Japan Refrigeration & Air Conditioning Industry Association
kWh – Kilowatt hour
NH₃ – Ammonia
METI – Ministry of Economy, Trade and Industry
MOFA – Ministry of Foreign Affairs
MOE – Ministry of the Environment
NEDO – New Energy & Industrial Technology Development Organization
NR – Natural Refrigerants
ODP – Ozone Depletion Potential
R290 – R-numbering identification for propane
R600a – R-numbering identification for isobutane
R744 – R-numbering identification for carbon dioxide
R717 – R-numbering identification for ammonia
R&D – Research & Development
TC – Transcritical
UK – United Kingdom
US – United States

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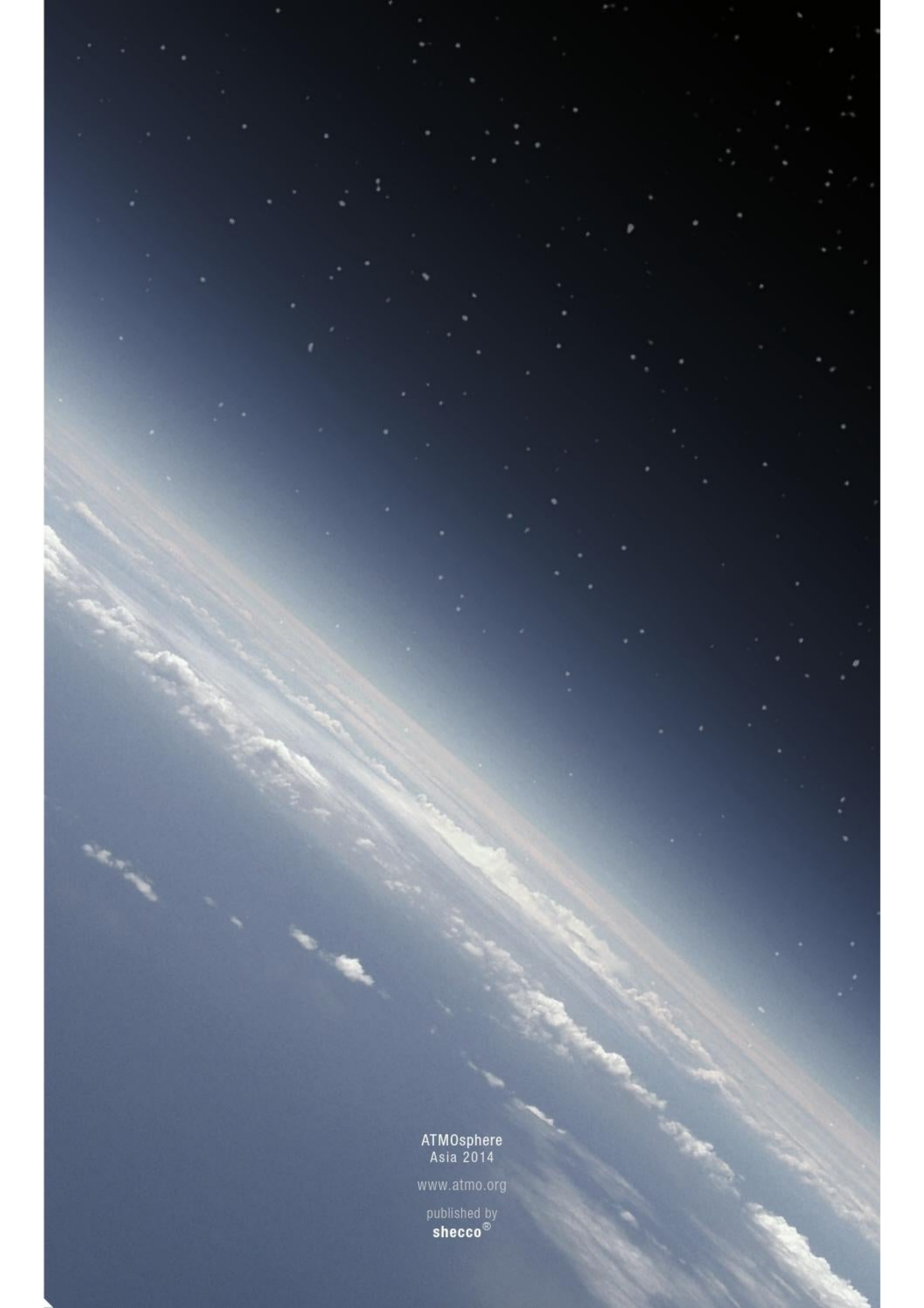
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