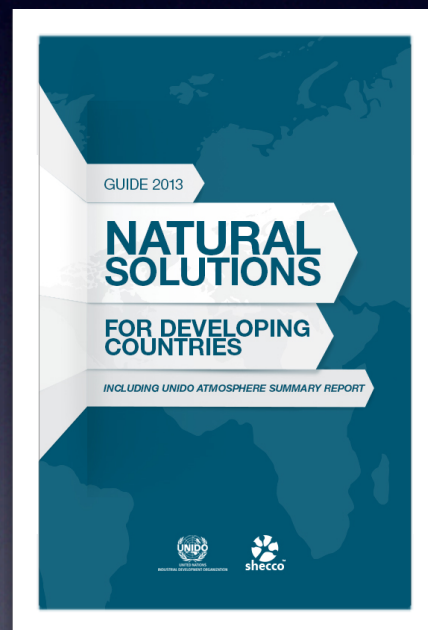


# GUIDE UNIDO

## Natural Solutions for Developing Countries: Case Studies, Trends & Survey Results



 **ATMO**  
UN **sphere**  
side event  
**natural refrigerants**  
24 October 2013, Bangkok

**Bangkok, 24 October 2013**

**Nina Masson, Head of Market Research**

**shecco**

# GUIDE UNIDO - overview



- **done in collaboration with United Nations Industrial Development Organization UNIDO**
- **objectives:**
- **summary of UNIDO ATMOSPHERE Technology Summit held in June 2013**
- **current & future market share for natural refrigerants & foam-blowing agents in developing countries - global survey**
- **barriers and how to address them, best practice case studies**

# GUIDE UNIDO - content



## NATURAL REFRIGERANTS & FOAM-BLOWING AGENTS

Natural refrigerants have been in use since the 19<sup>th</sup> century. As a general differentiation, "natural refrigerants" are substances that exist naturally in the environment, while "non-natural refrigerants" or "synthetic refrigerants" are man-made chemicals, not naturally occurring in nature. The most commonly used natural refrigerants today are ammonia (NH<sub>3</sub>, R717), carbon dioxide (CO<sub>2</sub>, R744), and hydrocarbons (HCs), such as propane (R290), isobutane (R600a), and propylene, also known as propene (R1270). Water and air are also used, to a lesser extent, for example in adsorption chillers and deep-freezing applications. Both hydrocarbons and carbon dioxide can be used in foam applications as blowing agents.

### ABOUT THE "NATURAL FIVE"

The "natural five" – air, ammonia, carbon dioxide, hydrocarbons and water – have distinct characteristics that make them viable options for a wide range of heating, cooling and foam applications.

**NH<sub>3</sub>** Ammonia (ODP= 0 / GWP= 0): Ammonia is a colourless gas at atmospheric pressure. With zero ozone-depleting and global warming potential, as well as a short atmospheric lifetime, it does not form any by-products or decomposition products with negative environmental impact. It is compatible with some, but not all, commonly used refrigeration system lubricants. Despite its undisputed energy efficiency benefits, the use of ammonia is restricted in certain applications and geographic regions, due to its toxicity and flammability. It is therefore mostly used in less populated areas or outside confined spaces. In recent years, advances have been made to minimise the NH<sub>3</sub> charge, by using it together with other refrigerants – such as CO<sub>2</sub> – in secondary systems, by using advanced safety systems, or by using ammonia absorption technology.

Ammonia is one of the most commonly applied refrigerants in the fisheries, food & beverages industry, in industrial transport refrigeration (cargo ships), cold rooms and special applications (such as ice rinks, deep mining and laboratories). It is also suitable for supermarket central refrigeration units as well as in district heating and cooling for public and office buildings. Large ammonia chillers are used in airports and hospitals.

**CO<sub>2</sub>** Carbon dioxide (ODP= 0 / GWP= 1): Carbon dioxide as a gas is colourless, odourless, and heavier than air. With a Global Warming Potential = 1, CO<sub>2</sub> is the reference value for comparing a refrigerant's direct impact on global warming. Carbon dioxide carries an A1 safety classification (the same as most fluorocarbon refrigerants), indicating that it has low toxicity and is non-flammable, as defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers ASHRAE under Safety Standard 34. CO<sub>2</sub> refrigerant is sourced as a by-product from a number of production methods. With a long atmospheric lifetime, CO<sub>2</sub> does not lead to any by-product formation with serious environmental impact. When used as a refrigerant, carbon dioxide typically operates at a higher pressure than fluorocarbons and other refrigerants. While this presents some design challenges, it can be overcome in systems designed specifically to use CO<sub>2</sub>. Carbon dioxide is compatible with some, but not all, commonly used refrigeration system lubricants.

CO<sub>2</sub> can be adopted in a large variety of heating and cooling systems, such as mobile air-conditioning (MAC) in passenger cars and buses, vending machines and coolers, central refrigeration systems for food retail applications, cold storage warehouses and the food processing industry, heat pump water heaters and space heating, as well as transport refrigeration like refrigerated trucks and trailers.

**Foams:** CO<sub>2</sub> as natural blowing agent can be used in various types of foam production like rigid polyurethane (PU) spray foams used in pipe and appliance insulation. CO<sub>2</sub> also has applications in flexible polyurethane foams in elastostock and boxfoam and in PU integral skin. Many large manufacturers have successfully used the technology for decades worldwide.

## SUCCESS STORIES OF NATURAL SUBSTANCES

### INDUSTRIAL REFRIGERATION

NH<sub>3</sub> freezing systems are successfully used in the food processing and the fishery industries in Argentina, Brazil, Colombia, India, Indonesia, and the Philippines, among others. However, whilst over 90% of the industrial refrigeration and cold storage industry in developed countries rely on ammonia, and to a minor extent on CO<sub>2</sub> and hydrocarbon refrigerants, the market share in developing countries is still much lower, currently at 40%.

### LIGHT-COMMERCIAL & COMMERCIAL REFRIGERATION

In the light-commercial industry, around 1 million ice cream freezers using hydrocarbons are now being applied in developed and developing countries. Moreover, another 1.8 million HFC-free bottle coolers and vending machines use either HCs or CO<sub>2</sub>.

In the commercial refrigeration sector, supermarkets can save 10%-35% energy by applying a CO<sub>2</sub>-only transcritical refrigeration system compared to conventional solutions in low- and medium ambient temperatures. Regarding market penetration, first results from a September 2013 survey indicated the number of stores using CO<sub>2</sub>-only transcritical systems in the European Union to be above 2,800, with another 1,500+ using CO<sub>2</sub>/HFC cascade systems. By early 2013, more than 125 supermarkets in North America used secondary, cascade and transcritical CO<sub>2</sub> refrigeration systems combined, and another 150+ stores in Japan are expected to be using CO<sub>2</sub> transcritical systems by the end of 2013. There are now at least 160 cascade CO<sub>2</sub> systems being used in Australia, and another 40 CO<sub>2</sub> cascade refrigeration systems installations in Brazil (both September 2013). Venezuela and Colombia are also introducing supermarkets with CO<sub>2</sub>-based refrigeration technology, and in South Africa some large supermarket chains have begun to convert their refrigeration systems to CO<sub>2</sub>, with 17 stores in South Africa now being equipped with CO<sub>2</sub>-only systems. Market uptake for natural refrigerants in food retail is also expected to grow in China, up from 8 supermarkets using CO<sub>2</sub> cascade systems today. With the support of

global consumer brands and international food retailers, hydrocarbon and CO<sub>2</sub> cooling equipment is being introduced to, amongst other countries, Turkey, Thailand, Indonesia, India, China, Mexico.

### DOMESTIC REFRIGERATION

In the domestic refrigeration sector, developing countries account for about 12% of global consumption of HFCs as refrigerants and blowing agents. Regarding the use of natural refrigerants, more than 650 million hydrocarbon refrigerators had already been sold by 2012 with the market experiencing a strong upwards trend. In Asia, HC refrigerators have been adopted in India, Indonesia, Japan, Pakistan and Russia. 75% of new domestic refrigerators/freezers produced in China use isobutane refrigerant (R-600a). In South America and the Caribbean, Argentina, Brazil, Cuba and Mexico are introducing hydrocarbon refrigerators into their domestic markets. Africa has also set up its first production line for hydrocarbon-based units in South Africa. It is predicted that 75-80% of new refrigerators worldwide will use HC refrigerants by 2020.

### DOMESTIC & MOBILE AIR CONDITIONING

The air-conditioning industry is one of the main consumers of high global warming HCFC refrigerant gases. Several Article 5 countries have started to seriously look into the use of hydrocarbon R290 as a viable alternative for small unitary air conditioning units. In India, more than 3,000 R290 room air conditioners had been sold by July 2012. Several leading Indian and Chinese air conditioner manufacturers have finalised R290 air conditioner production line conversion with the support of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and UNIDO. In total, China has committed to converting 35 of such plants to hydrocarbon-based technology.

Around 20 million cars use hydrocarbons as a refrigerant for mobile air conditioning systems, mostly in Australia and North America, but

about 5 natural refrigerants & foams


success stories of natural substances worldwide

# GUIDE UNIDO - ATMOSphere



## UNIDO ATMOSPHERE TECHNOLOGY SUMMIT: OVERVIEW

From 3 to 4 June 2013, the UNIDO ATMOSPHERE Technology Summit was held at the United Nations headquarters in Vienna, Austria. Jointly co-organised by UNIDO and market development company shecco, the summit brought together 150 participants from developing and developed countries. Titled "Natural Solutions for Developing Countries" the Summit focused on gases with low global warming potential, especially natural substances, for the heating, refrigeration & air-conditioning sectors, as well as for the foam sector. Substances considered included all five natural substances CO<sub>2</sub>, ammonia, hydrocarbons, water and air.



Co-chaired by Mr Sidi Menad Si Ahmed, Director of the Montreal Protocol Branch of UNIDO, and Marc Chasserot, Managing Director of shecco, the event's main purpose was to support developing countries in their efforts to find efficient, safe and sustainable solutions to replace hydrochlorofluorocarbons (HCFCs) in both the HVAC&R and foam sectors, and avoid substances with high Global Warming Potential.

The conference programme was designed to address topics of particular concern to developing countries, among them technology availability, cost-effectiveness over time as well as other barriers relating to safety, training, and regulatory frameworks. Case study presentations were combined with panel discussions generating lively debates between speakers and audience members, amongst whom were included system and component suppliers, end-users, national and international policy representatives, non-profit organisations, and the academic sector.

Over 40 invited speakers from Europe, Africa, West Asia, South-East Asia, North and South America discussed viable substances and technologies to fit specific applications, industry sectors, countries and/or climatic regions.

## UNIDO ATMOSPHERE: MARKET & TECHNOLOGY TRENDS

Atmosphere Technology Summit, representatives from Article 5 natural experts worldwide acknowledged ammonia as a very low Global Warming Potential (GWP) and zero Ozone Depletion Potential to be used as a main alternative to HCFCs in the industry of developing countries. In his presentation, Professor Vincent Grass from the University of Illinois, considered ammonia chillers to be a viable solution for developing countries. Developments such as microchannel condensers and NI brazed plate heat exchangers made the safe use of ammonia possible in low-charge applications.



System manufacturer Mayekawa presented various case studies on ammonia, carbon dioxide and water as refrigerants in food production centres, as well as the successful application of hygroscopic plants in many developing countries. The supplier's refrigeration packages are used in Serbia, Bosnia Herzegovina, Slovenia, Russia and Egypt. According to Mr Delorge, the demand for frozen food in developing countries will result in a need for refrigeration systems that can be met by ammonia plants.

Implementing efforts by the supplying industry to introduce natural refrigerants to developing countries. According to Vincent Grass from the University of Illinois, the company's 467 factories around the world use ammonia and CO<sub>2</sub> systems.

CO<sub>2</sub> systems are increasingly being introduced in retail sector in Article 5 countries such as South America. Various component manufacturers, including Danfoss, Carver and others, presented successful business models for CO<sub>2</sub> systems.

Download all presentations at: <http://www.ATMO.org/events/sections.php?id=977>

“Each of these main alternatives that I have shown are excellent and very competitive. They need to be treated with understanding to maximise the opportunities.”  
- Predrag Hrnjak, University of Illinois

“With regards to our sales we can say that we are present in over 80% of Article 5 countries with natural refrigerant compressors. So, we believe that the knowledge and experience to service and to operate these units with natural refrigerants is present in the field, and that the technology based on natural refrigerants will continue to become more efficient and more cost effective. We are sure of that.”  
- Eric Delorge, Mayekawa

“As a UN agency we have to be technology neutral, but I also strongly believe that it is our duty and mandate to promote new technologies for the benefit of the developing countries.”  
- Sidi Menad Si Ahmed, Director of the Montreal Protocol Branch, UNIDO

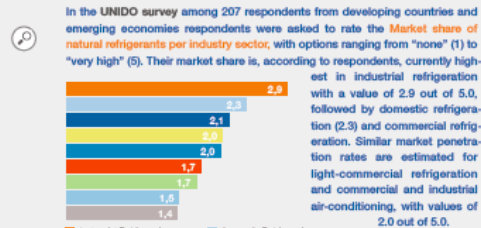
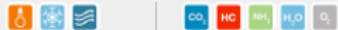
summary from the UNIDO ATMOSPHERE Technology Summit

- 3-4 June 2013
- Vienna, UNIDO Headquarters
- 200 stakeholders from developed and developing countries
- discuss practical solutions for overcoming challenges to the introduction of natural substances

# GUIDE UNIDO - content

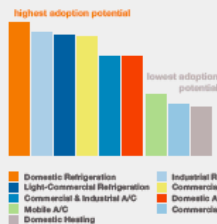


## SURVEYS: MARKET SHARE & ADOPTION POTENTIAL OF NATURAL SUBSTANCES



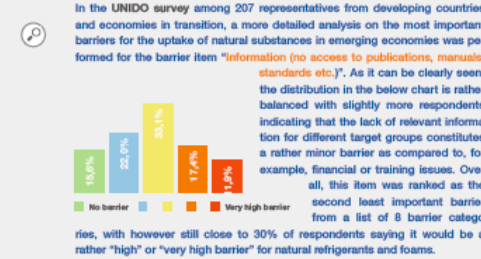
*Sectors with a continued use of natural refrigerants in different world regions, such as the use of ammonia in industrial refrigeration or the quickly increasing application of hydrocarbons in domestic refrigerators, will continue to be responsible for growing markets in developing markets in the near future. The simultaneous introduction of HFC-free appliance foams plays an important role in this respect. Other applications, among them small-size commercial plug-in display refrigeration equipment and centralised food retail refrigeration systems also show promising prospects. Domestic, as well as commercial and industrial heating, on the other end, currently enjoy less trust among respondents.*

Participants were next tasked to rank application sectors from "lowest" (1) to "highest" (9) according to their **Adoption potential for natural refrigerants within the next 5 years**. The application sector with the highest potential for natural refrigerants compared to other industry sectors is the domestic refrigeration sector, pointing to an already widespread and growing use of hydrocarbons in domestic refrigerators and freezers. This is followed by industrial refrigeration, mainly dominated by the use of ammonia. Light-commercial refrigeration, such as plug-in display cabinets, bottle coolers, vending machines, etc., and commercial refrigeration are estimated to have a similarly good future adoption potential as compared to other sectors. On the other hand, domestic heating, and commercial & industrial heating are less likely to experience a rapid increase in natural refrigerant use, respondents estimate.



For questions about the survey:  
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## SURVEYS: AWARENESS & STAKEHOLDER INVOLVEMENT



However, when asked about the lack of **"Networks & stakeholder involvement (no knowledge exchange, lack of stakeholder proactivity)"**, respondents stated a less positive situation. Overall ranked as the 3<sup>rd</sup> strongest barrier from a list of 8 items, only 16% thought this is not currently a major problem for the introduction of natural refrigerants and HFC-free foams. The remaining overwhelming majority of 84% sees this as at least as a moderate if not a very high barrier.

Barrier Level	Percentage
No barrier	8.4%
Low barrier	10.1%
High barrier	41.2%
Very high barrier	21.1%
Very very high barrier	21.1%

In the UNEP survey among National Ozone Units from 79 countries in July 2012, the 3<sup>rd</sup> ranked criteria in selecting technologies with HCFC alternatives for developing countries was **"Familiarity: high knowledge of the technology / substance, proven number of successful installations, case studies"**. Although not specifically talking about natural refrigerants and foams it confirms that the availability of information among institutions, the industry and the wider public is a major driver for the selection of more sustainable substances and technologies. More importantly, the proven number of installations, publicised in case studies, can significantly help to counteract a lock-in situation where the familiarity with a known technology - although in some cases not the best available alternative - is the deciding factor for its use.

Barrier Level	Percentage
Not important	1.6%
Rather not important	3.2%
Rather important	18.0%
Very important	78.2%

*While information provision in form of direct access of stakeholders to relevant publications seems to constitute a slightly less important barrier overall, the lack of effective networks and proactive stakeholder engagement is rated as being a strong obstacle for the introduction of natural substances.*

survey among 200+ individuals from developing countries

# GUIDE UNIDO - content



## JOHNSON CONTROLS: FIRST LARGE-SCALE NH<sub>3</sub>/CO<sub>2</sub> CASCADE SYSTEM IN JORDAN



In 2007 "Jordan Poultry" placed an order with the Sabroe Factory in Denmark. The cascade system was installed in August 2012 outside Amman in Jordan. The plant is for freezing poultry products for the Jordanian and Middle East markets. The climate in this region is quite challenging because of the very big temperature differences seen over the year. The summer is warm and hot and the winters can be very cold and even snow is seen but it tends to melt away very quickly.

The plant is a cascade system with three ammonia (NH<sub>3</sub>) screws on the high temperature side of the system and carbon dioxide (CO<sub>2</sub>) on the low stage. The new system was built in a new machine house with space for additional compressors on both the ammonia side and the CO<sub>2</sub> side.



The products are frozen at a temperature of around -40°C in two air-cooled batch freezers. Also a chilling tunnel for cooling the fresh killed chicken is using CO<sub>2</sub> circulated at -10°C and a tunnel temperature about +1°C. Also a falling film ice water cooler is cooled with CO<sub>2</sub> at -10°C.

The NH<sub>3</sub> system is using an evaporative condenser, which ensures the lowest possible condensing temperature in the dry summer. The freezing of the product lasts about 3 hours to reach the required temperature. The product is wrapped in to the final packing. It can differ and the products are not totally uniformly packed. This not a problem but increases the process time a little.

The food quality and food safety of the product has a very high priority for the producer. Therefore there is a focus on hygiene and temperature control. It is here the cascade system play a role to keep temperature within the required limits quickly after the process in the cooling tunnel. Also a quick freezing process is help keeping a high product quality.

The reason for investing in CO<sub>2</sub> technology in an environment where R22 is still allowed was the intention to future-proof the investment. Industrial refrigeration systems have an expected lifetime of 25 years. The installed system therefore provides investment security to the operator to face any potential restriction on the use of high-GWP refrigerants in the future.



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CASE STUDY: JOHNSON CONTROLS

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Jordan

*Jordan's first large-scale NH<sub>3</sub>/CO<sub>2</sub> system was installed by Sabroe in a poultry processing plant outside Amman. The system was designed to ensure highest food quality and safety.*

*The project was engineered and project-managed by the factory's employees to ensure highest familiarity with the operation and maintenance of the installed system.*

*The natural refrigerant solution ensures investment security for the plant operator who has invested in a long-term solution not affected by any potential change in legislation on high-GWP substances.*

## CITY AMMONIA 'PLUG AND PLAY' CHILLERS INSTALLED IN AFRICA



Zimbabwe, Angola, Tunisia

At Nestlé in Africa, several small capacity ammonia chillers are installed: In Zimbabwe there are 4 installations of 90kW, and Tunisia 2 installations

achieved by the ammonia chillers compared to 12 tonnes CO<sub>2</sub> per year, equivalent to driving 2 times a 4HP diesel vehicle.

*Eight "plug and play" ammonia chillers for air-conditioning in three African countries have each led to a reduced carbon footprint of 12 tonnes CO<sub>2</sub> per year.*

<http://www.ammonia21.com/news/view/3394>

[http://www.almco.org/media/presentation\\_pch\\_7d-232](http://www.almco.org/media/presentation_pch_7d-232)

## CAMPAIGN PROMOTING HYDROCARBON DOMESTIC AIR-CONDITIONING IN INDIA ACHIEVES SUCCESS



India

Campaign was created by two organisations from the hydrocarbon (HC) domestic air-conditioning industry. It achieved an initial success by involving local organisations of Management Ahmedabad (IMA) and members of hydrocarbon ACs. The campaign aims to promote the use of hydrocarbon ACs such as reduced energy consumption and

an innovative method to involve related industry players of hydrocarbon ACs. It allows stakeholders to adopt various ways, as: Voluntary adopters, Consumer Ambassadors and Technical Ambassadors.

*A partnership campaign between a European NGO and an Indian partner company has involved various stakeholder groups as ambassadors for hydrocarbon domestic air-conditioning in India.*

<http://www.hydrocarbons21.com/news/view/4361>

64

50+ case studies

- best-practice examples from developing countries only
- addressing the barriers of awareness, availability, safety & technology standards, policy frameworks, training & knowledge, incentives & cost

# HFC-free domestic refrigeration



**about 50% of new  
domestic refrigerators  
use HCs**

# HFC-free light-commercial refrigeration



**GLOBAL  
2013  
Bottle Cooler**  
1,650.000+



**GLOBAL  
2013  
Ice Cream Freezer**  
1,050.000+



**EUROPE  
2013  
Bottle Cooler**  
1,250.000+



**EUROPE  
2013  
Ice Cream Freezer**  
800.000+



**min. 2.5 million HFC-free units worldwide**



# HFC-free industrial refrigeration



**90% NH<sub>3</sub> use in  
developed - 40% in  
developing countries**

# global CO<sub>2</sub> transcritical stores



**approx. 3,000 CO<sub>2</sub>  
transcritical stores**

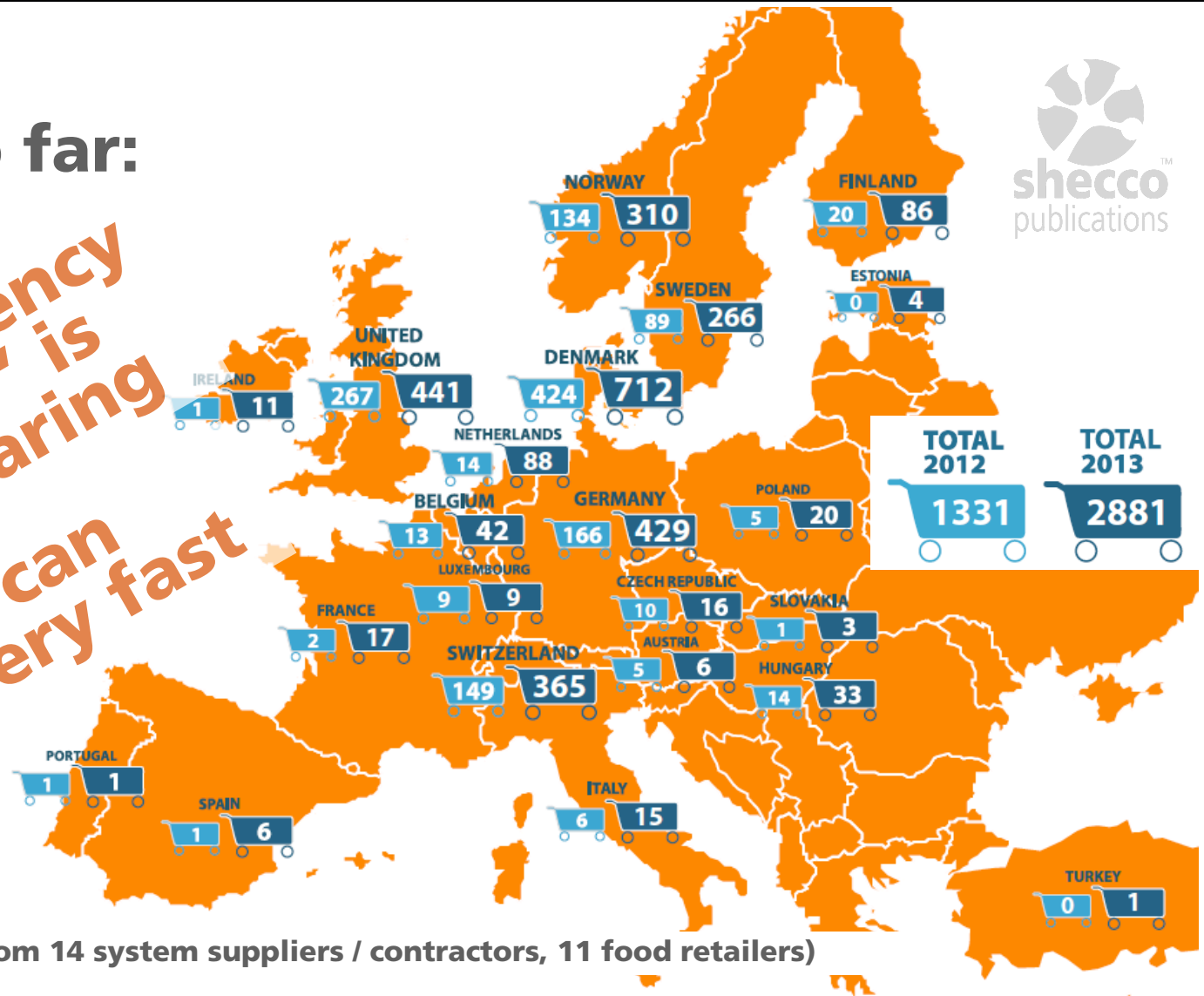
**technology moving from north to south**

# CO<sub>2</sub> TC stores: europe 2013



verified so far:

*“CO<sub>2</sub> efficiency equator” is disappearing  
change can happen very fast*



(status Sept 2013, data from 14 system suppliers / contractors, 11 food retailers)

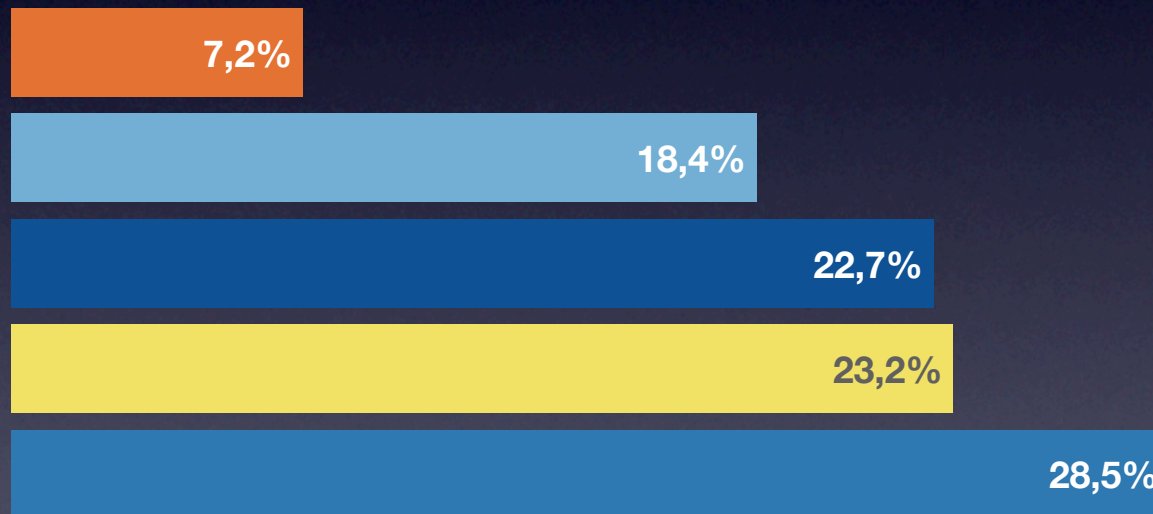
# (HFC-free) commercial refrigeration



# surveys in the GUIDE UNIDO



- 2 surveys taken into account: UNIDO (May-July 2013) among 207 respondents
- UNEP (May-July 2012) among 95 National Ozone Unit Officers

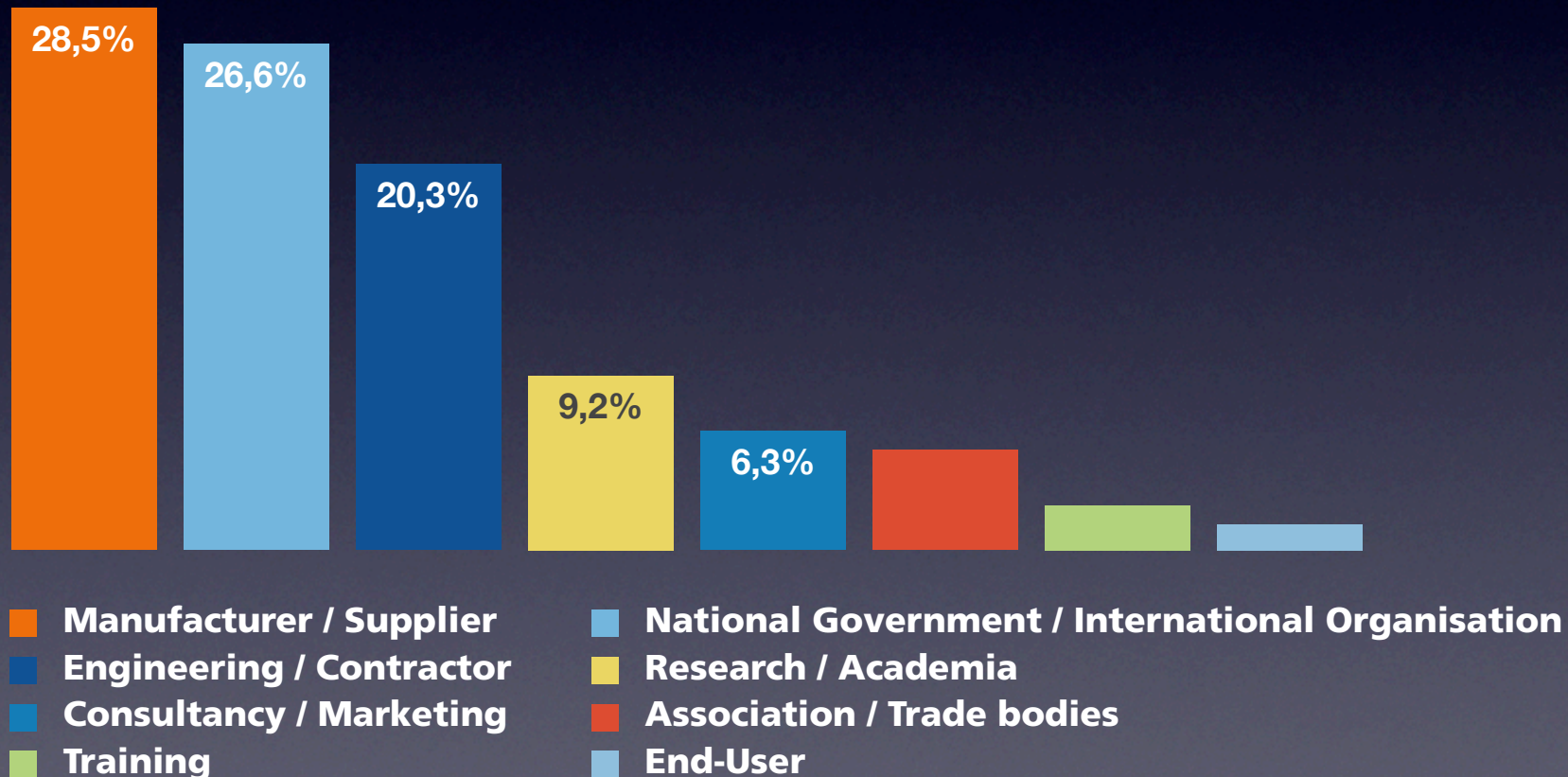


- Arab States
- Africa
- Europe and NIS
- Latin America and the Caribbean
- Asia and the Pacific

# UNIDO survey: respondents



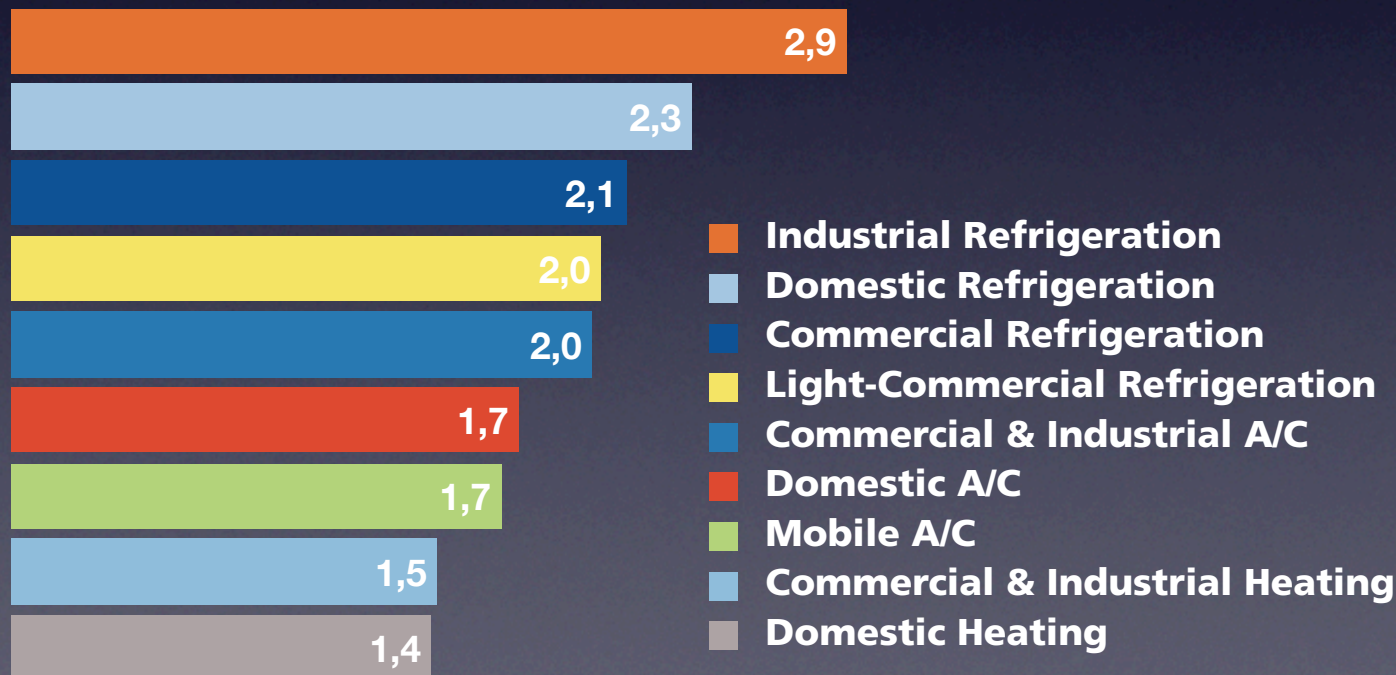
- manufacturers & suppliers, national governments and engineering / contractors are the main response groups



# current market share of NR



- natural refrigerants are currently mostly used in industrial refrigeration
- domestic refrigeration, commercial refrigeration, light-commercial refrigeration, and commercial / industrial AC in developing countries have promising adoption
- overall, market shares are still small on a scale from 0 (“none”) to 5 (“very high”)



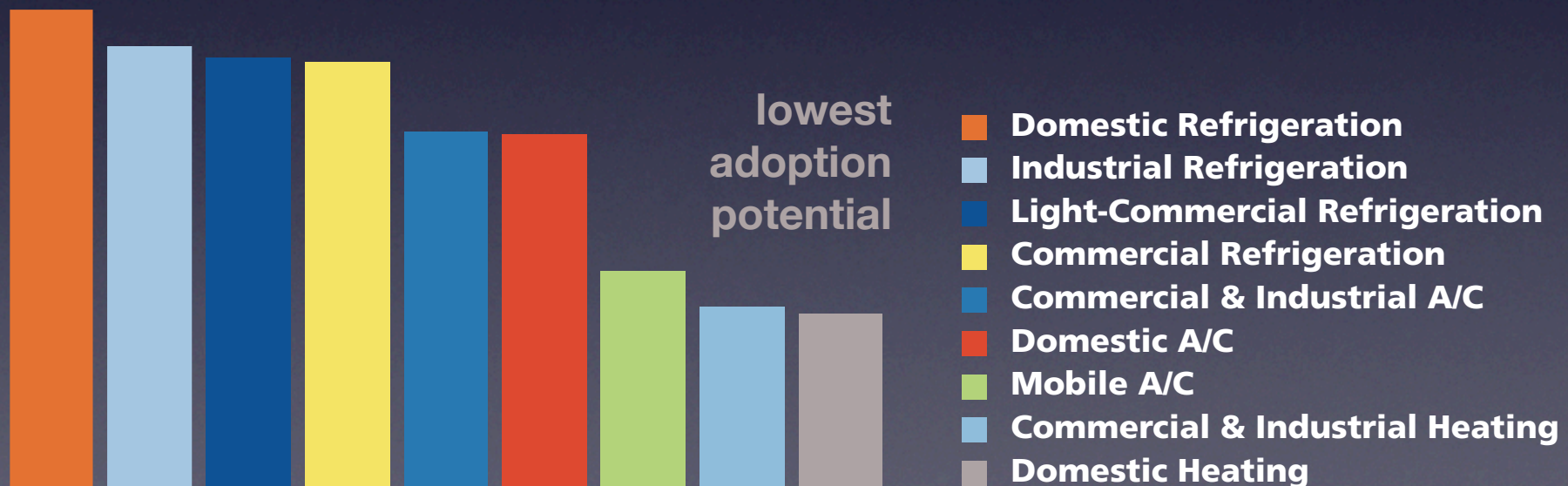
source: shecco / UNIDO survey, scale: 0 (“none”) to 5 (“very high”)

# NR adoption potential in the next 5 years



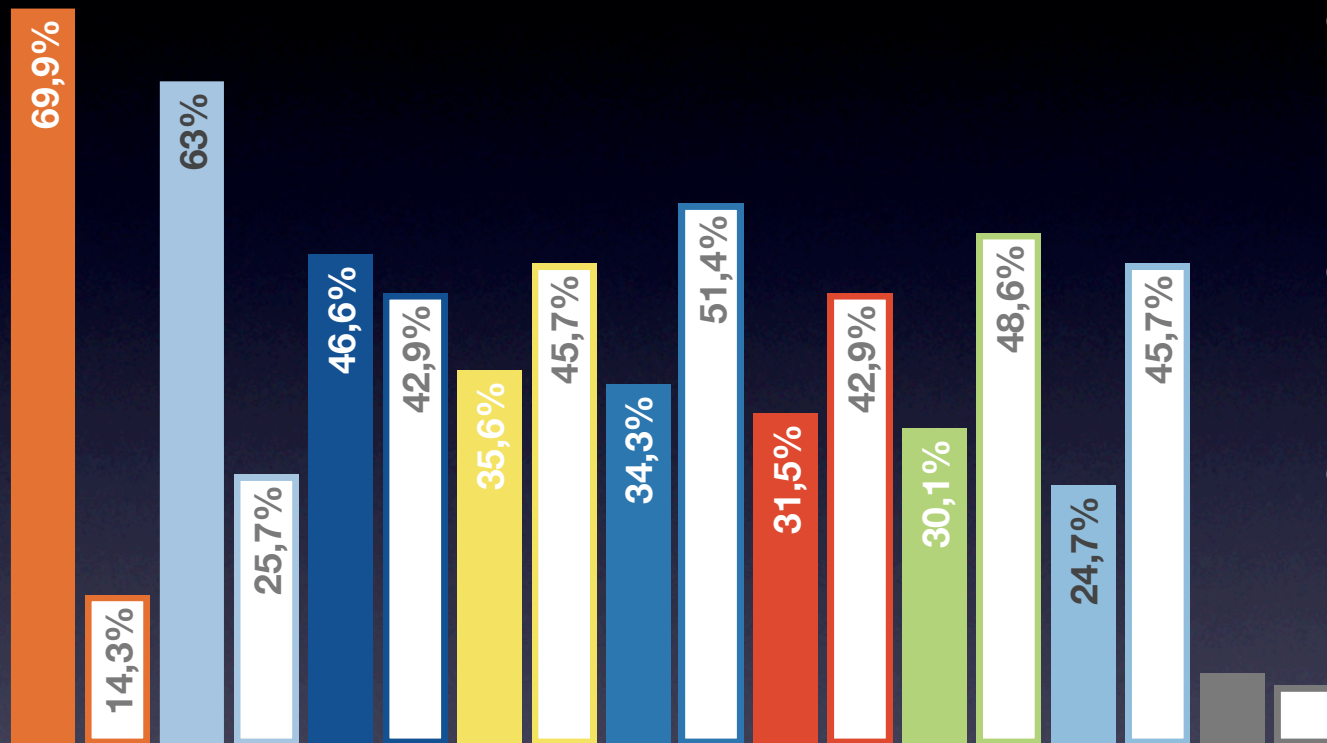
- ⦿ domestic refrigeration will show the largest increase in adoption in the next 5 years in developing countries (proven technology with 650 million HC units)
- ⦿ industrial refrigeration, light-commercial and commercial refrigeration will be very promising

**highest adoption potential**





# reasons for and against adopting NR



- Environmental impact - driver
- Efficiency & reliability - driver
- Training & knowledge - driver
- Safety & standards - driver
- Market demand - driver
- Cost of substance - driver
- Availability & supply - driver
- Cost of technology - driver
- Other - driver

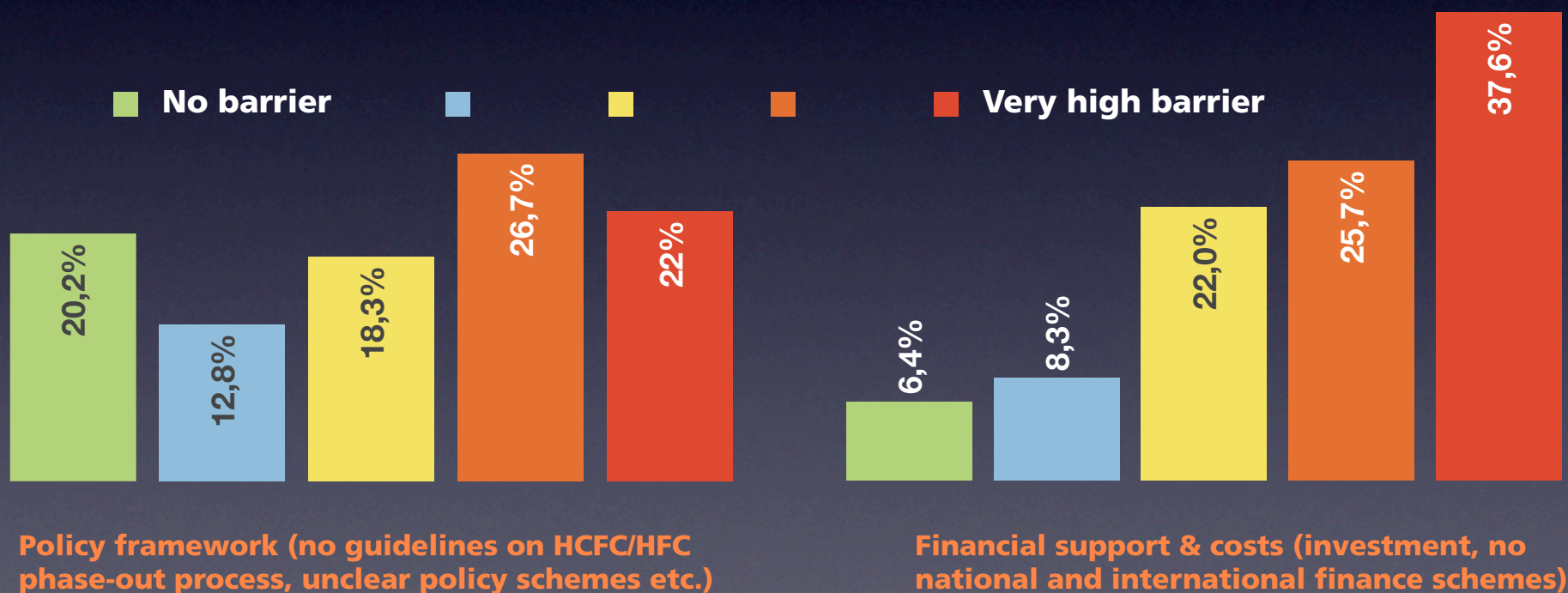
- Environmental impact - barrier
- Efficiency & reliability - barrier
- Training & knowledge - barrier
- Safety & standards - barrier
- Market demand - barrier
- Cost of substance - barrier
- Availability & supply - barrier
- Cost of technology - barrier
- Other - barrier

- the environmental impact is a clear driver, together with efficiency & reliability
- training & knowledge is both a driver and a barrier
- the cost of technology, availability & supply, and market demand are areas of concern (= largest discrepancy between driver and barrier)

# the importance of clear policy frameworks & incentives



- nearly half of all respondents believe unclear policy frameworks to be a high to very high barrier in the HCFC phase-out process
- lack of financial incentives and currently too high costs for HFC-free technology is the single strongest barrier out of a list of 8






# case: CO<sub>2</sub>/NH<sub>3</sub> system in China



**DANFOSS: VALVES FOR LANDMARK CO<sub>2</sub> SYSTEM IN ZHANGZI COLD STORAGE**




**CO<sub>2</sub>** **NH<sub>3</sub>**

Danfoss's award winning valve station for industrial refrigeration, called ICF Flexiline™, recently achieved a major milestone in China. The whole Flexiline™ family of valves were extensively applied in a landmark CO<sub>2</sub> refrigeration project at the scallop & sea cucumber processing centre of the Dalian Zhangzi Island Fishery Group.

After comprehensively considering safety, the environment, and efficiency, the Zhangzi Island group decided to use CO<sub>2</sub> as the refrigerant for this project. Danfoss was subsequently selected as the valve supplier due to its industry leading CO<sub>2</sub> technology, vast experience with CO<sub>2</sub> and high-quality products.

In the newly developed seafood processing centre, the freezing plant utilizes a NH<sub>3</sub>/CO<sub>2</sub> cascade system for refrigeration, which lower the NH<sub>3</sub> charge amount by over 90% and limits the NH<sub>3</sub> refrigerant inside of the refrigeration control room, fully satisfying the safety requirements of Zhangzi Island group.

The cold storage plant utilizes a CO<sub>2</sub> brine system and uses the abundant sea water as the cooling medium for the high level ammonia refrigeration. The setting up of the condenser heat recovery appliance prior to the cooling process, realized a good balance between safety and environment protection.



Seafood processing depends heavily on reliable refrigeration systems. This is the main reason why Danfoss CO<sub>2</sub> solutions and components were used for the Zhangzi Island project. With leading TDR technology, Danfoss AKS 4100U series radar liquid level sensor was adopted for liquid level controlling of the NH<sub>3</sub>/CO<sub>2</sub> cascade system, working together with the ICM series motor control valve for precise control of the refrigeration liquid level control. The feeding line of the freezing room uses the Danfoss premier product ICF series valve station, which compressed the installation area by 2/3 and reduced the welding time by 80%. The newly launched SVL Flexiline™ series of refrigeration line components were also widely used.

*In a landmark project in China, the new Zhangzi sea food processing centre uses a NH<sub>3</sub>/CO<sub>2</sub> cascade system for refrigeration. This has lowered the NH<sub>3</sub> charge amount by over 90% and limits the NH<sub>3</sub> refrigerant inside of the refrigeration control room. The cold storage plant utilizes a CO<sub>2</sub> brine system and uses the abundant sea water as the cooling medium for the high level ammonia refrigeration.*

*Danfoss supplied its Flexiline™ valve station for CO<sub>2</sub> solutions extensively throughout the entire system, raising safety and reliability while reducing welding time by 80%.*

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CASE STUDY: DANFOSS 49

- major milestone in China
- Zhangzi seafood processing plant uses cascade refrigeration system and CO<sub>2</sub> brine system for the cold storage
- lowered ammonia charge by 90%
- use of sea water as the cooling medium for the high level ammonia refrigeration
- use of globally available mature CO<sub>2</sub>-ready valves reduced welding time by 80%

# case: ammonia freezers in Viet Nam & Malaysia



## DSI: AMMONIA PLATE FREEZERS FOR FISH AND SHRIMP IN VIET NAM AND MALAYSIA



DSI has over the years sold many freezers for the seafood industry in Asia. In a more recent project it supplied Horizontal Plate Freezers operating on ammonia for freezing fish and shrimp in Viet Nam and Malaysia. The freezers are connected to a central refrigeration system with pump circulation for efficient freezing.



End-users of ammonia plate freezers are mainly fish factories that are exporting some of their products to the USA, Europe and other markets. By choosing the NH<sub>3</sub> freezers the fish processors get a very reliable solution made for operation in a tough environment. A focus was put on a high quality and high efficiency of the system. Moreover, a short freezing time, a robust construction, cleaning friendliness, hygiene and minimal maintenance were important.



All DSI freezers are made to operate on natural refrigerants like NH<sub>3</sub> and CO<sub>2</sub>.

DSI Horizontal Plate Freezers feature a low power consumption, are easy to maintain and clean. The element surface structure prevents dents and marks in the packaging. The most common block dimensions can be produced in this type of freezer. The freezer is made with a heavy-duty hotdip galvanised steel frame and is mounted with hydraulic twin rams ensuring a stable and even plate pressure which guarantees homogenous blocks. The fast low temperature freezing maintains the natural quality of the product.

Horizontal ammonia plate freezers are suitable for the freezing of shrimps, filets in blocks, vegetables, H & G fish, and chopped products.

*The ammonia horizontal plate freezers for freezing fish and shrimp in Viet Nam and Malaysia have led to an increase in quality, cleaning friendliness, hygiene and maintenance of the system.*

*Moreover, it has improved system efficiency and lowered freezing time.*



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- use of horizontal plate freezers for freezing fish and shrimp that will be exported to Europe / USA
- very reliable solution ready for operation in tough climatic conditions
- focus was put on high quality and efficiency of the system - result was short freezing time, robust construction and minimal maintenance
- products suitable also for other frozen food like chopped products and vegetables



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# case: NH<sub>3</sub>/CO<sub>2</sub> system in Jordan



## JOHNSON CONTROLS: FIRST LARGE-SCALE NH<sub>3</sub>/CO<sub>2</sub> CASCADE SYSTEM IN JORDAN



In 2007 "Jordan Poultry" placed an order with the Sabroe Factory in Denmark. The cascade system was installed in August 2012 outside Amman in Jordan. The plant is for freezing poultry products for the Jordanian and Middle East markets. The climate in this region is quite challenging because of the very big temperature differences seen over the year. The summer is warm and hot and the winters can be very cold and even snow is seen but it tends to melt away very quickly.

The plant is a cascade system with three ammonia (NH<sub>3</sub>) screws on the high temperature side of the system and carbon dioxide (CO<sub>2</sub>) on the low stage. The new system was built in a new machine house with space for additional compressors on both the ammonia side and the CO<sub>2</sub> side.



The products are frozen at a temperature of around -40°C in two air-cooled batch freezers. Also a chilling tunnel for cooling the fresh killed chicken is using CO<sub>2</sub> circulated at -10°C and a tunnel temperature about +1°C. Also a falling film ice water cooler is cooled with CO<sub>2</sub> at -10°C.

The NH<sub>3</sub> system is using an evaporative condenser, which ensures the lowest possible condensing temperature in the dry summer. The freezing of the product lasts about 3 hours to reach the required temperature. The product is wrapped in to the final packing. It can differ and the products are not totally uniformly packed. This not a problem but increases the process time a little.

The food quality and food safety of the product has a very high priority for the producer. Therefore there is a focus on hygiene and temperature control. It is here the cascade system play a role to keep temperature within the required limits quickly after the process in the cooling tunnel. Also a quick freezing process is help keeping a high product quality.

The reason for investing in CO<sub>2</sub> technology in an environment where R22 is still allowed was the intention to future-proof the investment. Industrial refrigeration systems have an expected lifetime of 25 years. The installed system therefore provides investment security to the operator to face any potential restriction on the use of high-GWP refrigerants in the future.

*Jordan's first large-scale NH<sub>3</sub>/CO<sub>2</sub> system was installed by Sabroe in a poultry processing plant outside Amman. The system was designed to ensure highest food quality and safety.*

*The project was engineered and project-managed by the factory's employees to ensure highest familiarity with the operation and maintenance of the installed system.*

*The natural refrigerant solution ensures investment security for the plant operator who has invested in a long-term solution not affected by any potential change in legislation on high-GWP substances.*



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- installation in Aug 2012 in Amman = Jordan's first large-scale NH<sub>3</sub>/CO<sub>2</sub> system
- cascade system for freezing poultry during warm summers and cold winters
- use of three ammonia compressors, and three reciprocating CO<sub>2</sub> on the low stage side to freeze at -40°C and chilling at -10°C
- project was engineered and project-managed by the factory's employees, ensuring high familiarity with the system



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# case: global consumer goods brand



- Nestlé has a natural refrigerant policy since 1986 and uses 90% HFC-free ammonia, carbon dioxide and hydrocarbons solutions in its close to 500 factories in 86 countries
- has actively invested in training especially in developing countries and developed internal standards that go beyond many codes and regulations
- actions: “safe by design” service, training and education on natural refrigerants

**GLOBAL CONSUMER GOODS BRAND EXPANDS NATURAL REFRIGERANT USE**

Global consumer goods brands require effective solutions for their operations involving light-commercial, commercial and industrial refrigeration and air-conditioning processes in developing countries. During the 2013 UNIDO ATMOSphere Technology Summit, Nestlé introduced the company's experiences of dealing with natural refrigerants in developing countries. Nestlé introduced a series of solutions including standards-making, “safe by design” service, training, and education, on natural refrigeration.

Based on a clear corporate strategy to increase the use of HFC-free solutions in industrial facilities, Nestlé is currently seeking natural solutions for air conditioning systems. The company has now installed a 100kw NH<sub>3</sub> enclosed packaged ammonia chiller in a factory, and a centralised chilled water system with ammonia for its new regional head office in Africa. In China, CO<sub>2</sub> systems for small low temperature cold stores are installed in the northern part of the country. A centralised chilled water system with ammonia for a new R&D centre in India has also been established.

*Nestlé now has 468 factories in 86 countries, of which over 90% use ammonia, hydrocarbons and CO<sub>2</sub> systems.*

<http://www.ammonia21.com/news/view/4298>

<http://www.atmo.org/media.presentation.php?id=232>

# case: CO<sub>2</sub> heat pumps in China



- ◎ **Bumade station on the Qinghai-Tibet railway line:** three 50kW heat pumps are operating at 4,800m above the sea level for space and water heating - they work well even during winter at outside temperatures of -30°C = the highest in elevation and the lowest in operating temperature in the whole of China
- ◎ **Wuhan University:** 50% energy saving with CO<sub>2</sub> heat pump combined with an electric boiler for hot drinking water production since October 2011 (as compared to a 100% electric boiler) - 5 tons hot drinking water per day
- ◎ overall: 50-70 CO<sub>2</sub> heat pump projects in China and production capacity of 100,000 units / year

The infographic features a grey header with a globe icon and the title "CO<sub>2</sub> HEAT PUMPS ARE GROWING IN POPULARITY IN CHINA". Below the header are two icons: a flame in a circle and a CO<sub>2</sub> molecule. To the right is a world map with China highlighted in blue. The main text area contains three paragraphs of text, each preceded by a small circular icon. A grey box on the right contains a quote. At the bottom, there is a URL: <http://www.r744.com/news/view/3424>.

**CO<sub>2</sub> HEAT PUMPS ARE GROWING IN POPULARITY IN CHINA**

The CO<sub>2</sub> heat pump market is developing fast in China, with the technology being applied in hospitals, train stations, schools and public buildings.

**Heating Bumade Station on the Qinghai-Tibet railway line, at 4,800m above sea level:** Three 50kW CO<sub>2</sub> heat pumps were installed in a 3000 m<sup>2</sup> maintenance area of the Bumade railway station to provide space and water heating. According to supplier Melinda, the heat pumps work well even during winter when the outside temperature is as low as -30°C. The heat pump project is the highest in elevation and lowest in operating temperature in China.

**50% energy saving for hot drinking water production in Wuhan University:** A CO<sub>2</sub> heat pump water heater was installed in October 2011 in the Wuhan University of China to provide hot drinking water. The combined CO<sub>2</sub> heat pump and electric boiler saves 50% in energy for the university compared with a 100% electric boiler. The system is able to provide 5 tons hot drinking water per day to students.

*Increasingly more CO<sub>2</sub> heat pumps are used in space and water heating in China. A group of domestic manufacturers have emerged. Today there are more than 30 CO<sub>2</sub> heat pump installations across the country.*

<http://www.r744.com/news/view/3424>



# case: 17 CO<sub>2</sub>-only supermarkets in South Africa



- ◎ **Woolworths and Makro show leadership with combined 17 stores using transcritical CO<sub>2</sub> systems**
- ◎ **reduction in power consumption: 45%**
- ◎ **12% higher installation costs than R404a system**

**17 TRANSCRITICAL CO<sub>2</sub> STORES IN SOUTH AFRICA SAVE UP TO 45% ENERGY USE**

**South Africa**

In South Africa, 8 Woolworths stores and 9 Makro stores are currently running with trans-critical CO<sub>2</sub> systems using a common liquid line to the chillers and freezers with individual suction lines back to each section on the multiplex system i.e. freezer rack and chiller rack.

With all of the the controls being Danfoss with electronic expansion valves, pack controllers, heat exchangers and plate heat exchangers a reduction in power consumption of up to 45% was recorded. At this stage because of the size of some of the plants the CO<sub>2</sub>, as apposed to a 404 system, is costing about 12% more on installation costs. Each Makro store has two equal systems of 300KW each, 200kw chiller and 100kw freezer with a total refrigeration capacity per store of approximately 800kw. Woolworths has an average 300kw of refrigeration capacity per store.

*17 stores in South Africa now use a CO<sub>2</sub> transcritical system, with the result of up to 45% reduction in power consumption as compared to an R404 system.*

<http://www.r744.com/news/view/1049>

# cases around the world



**Zimbabwe, Angola, Tunisia:** "plug-and-play" ammonia chillers achieve carbon footprint reduction of 12 CO<sub>2</sub>/year, compared to R134a

**Pakistan:** 100% PU block slab now HCs; 51% of rigid foams cyclopentane; 5,000 R290 bottle coolers sold; 15,000 new R600a domestic refrigerators

**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

**China:** possible R290 A/C mass production possible

**Brazil:** first R600a water fountain commercially available

**Thailand:** retrofit of industrial A/C with HC blends achieve 20% energy savings

**Indonesia:** commercial A/C and refrigeration systems with R290 for 15% energy savings

# main messages



**solutions for different applications, world regions and climates are available. globally active suppliers already today deliver their products worldwide and constantly innovate. local initiatives are increasing.**

# industrial refrigeration trends in europe



**change can happen very fast but ambition is needed. it is necessary to set clear policy frameworks to ensure investment security.**

# shecco - useful links



## Industry Platforms:

<http://www.hydrocarbons21.com>

<http://www.R744.com>

<http://www.ammonia21.com>

<http://www.R718.com>

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## GUIDE UNIDO:

**on the MOP 25 website!**

**Other GUIDES (Europe; North America; CO<sub>2</sub>/NH<sub>3</sub> industrial refrigeration:**

<http://guide.shecco.com>

**ATMOsphere Europe 2013  
Summary Report:**

<http://www.ATMO.org>