

natural refrigerants - global trends & developments



technology & innovation

February 3, 2014

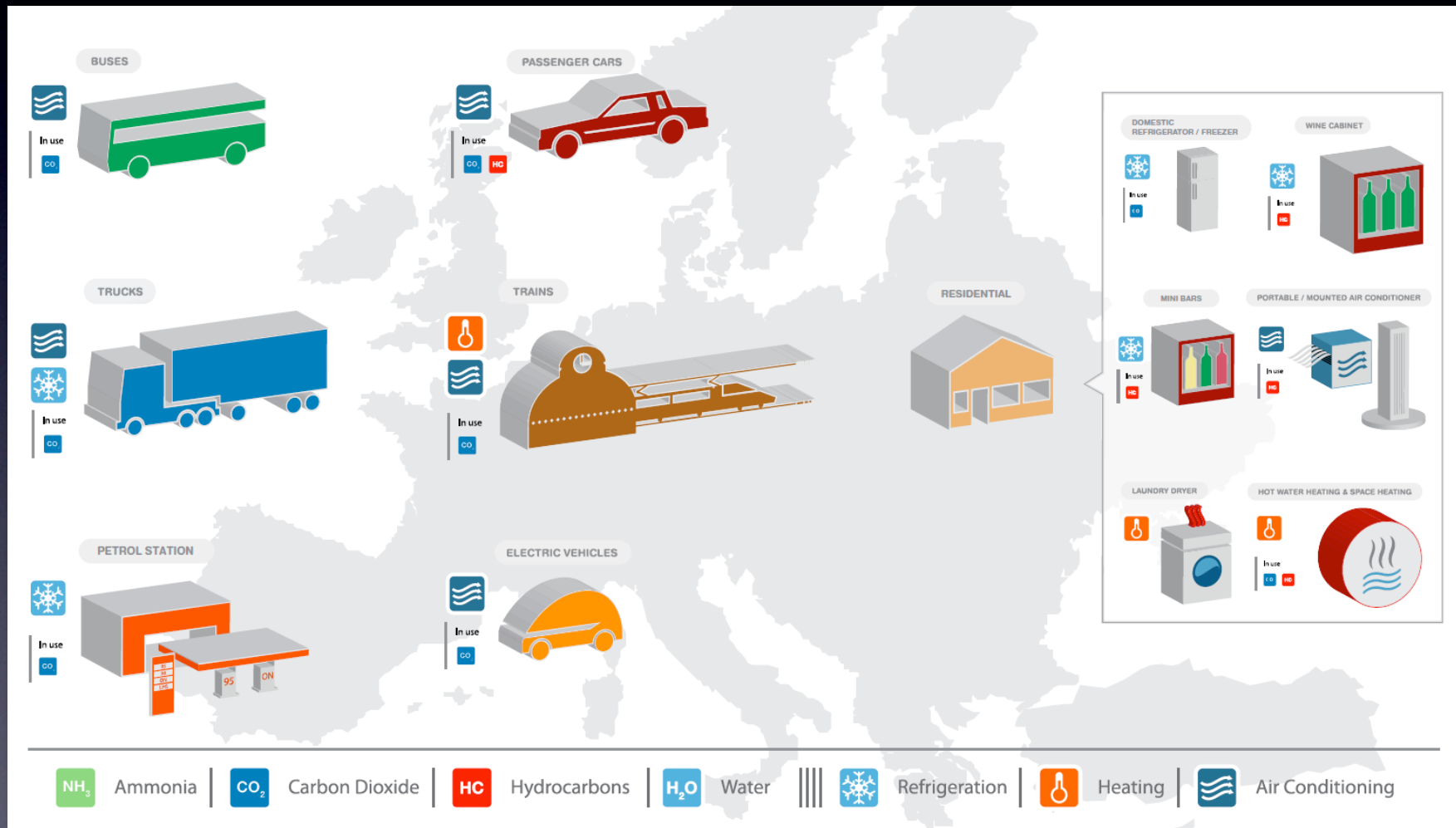
Nina Masson, Head of Market Research

shecco Japan

a wide range of applications for natural refrigerants



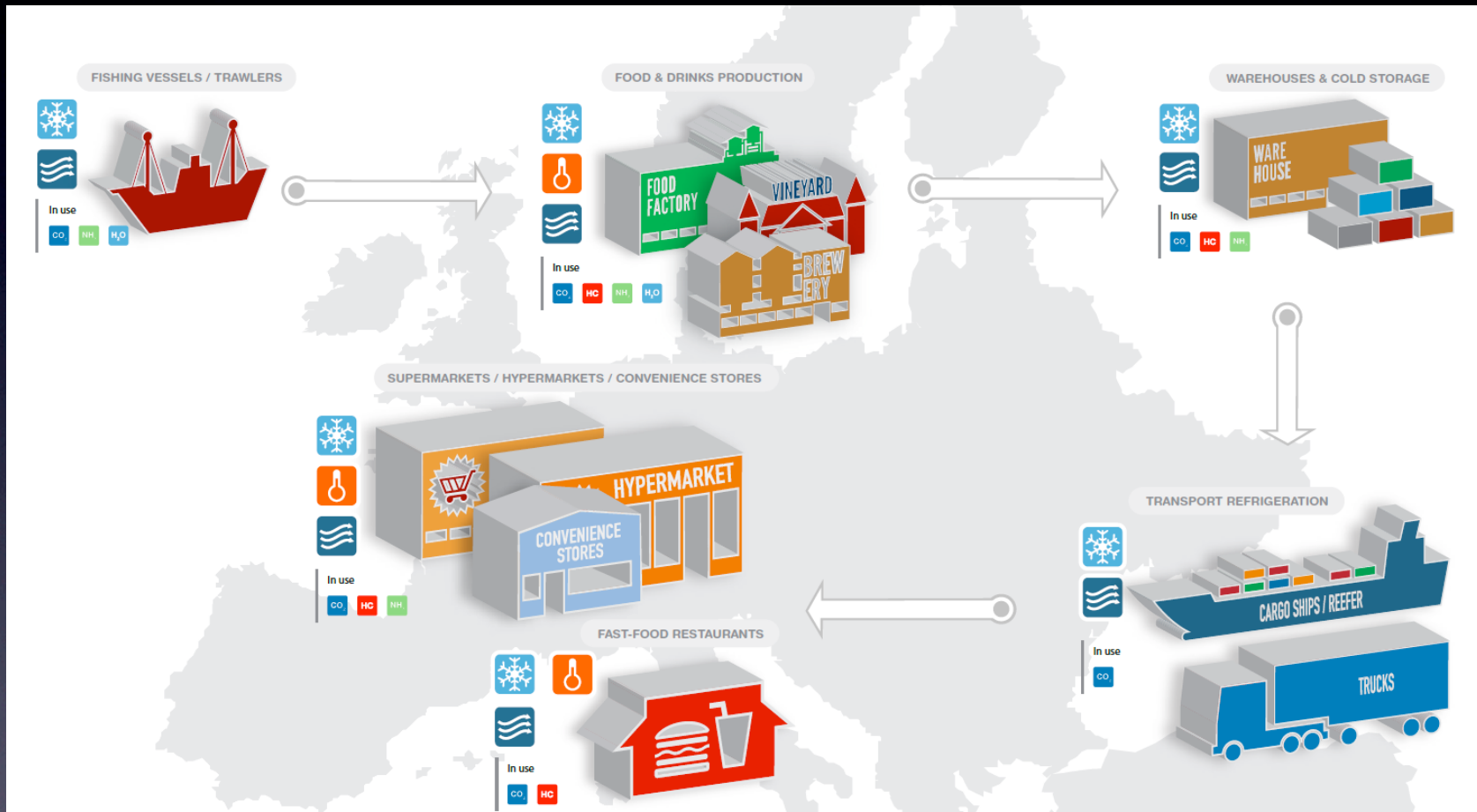
a wide range of applications for natural refrigerants



a wide range of applications for natural refrigerants



the food chain: a growing momentum for natural refrigerants



NH₃ Ammonia |
 CO₂ Carbon Dioxide |
 HC Hydrocarbons |
 H₂O Water |
 ||||
 Refrigeration |
 Heating |
 Air Conditioning

NH₃ Ammonia |
 CO₂ Carbon Dioxide |
 HC Hydrocarbons |
 H₂O Water |
 ||||
 Refrigeration |
 Heating |
 Air Conditioning

world: CO₂ transcritical & cascade commercial refrigeration



2018/01/12

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+

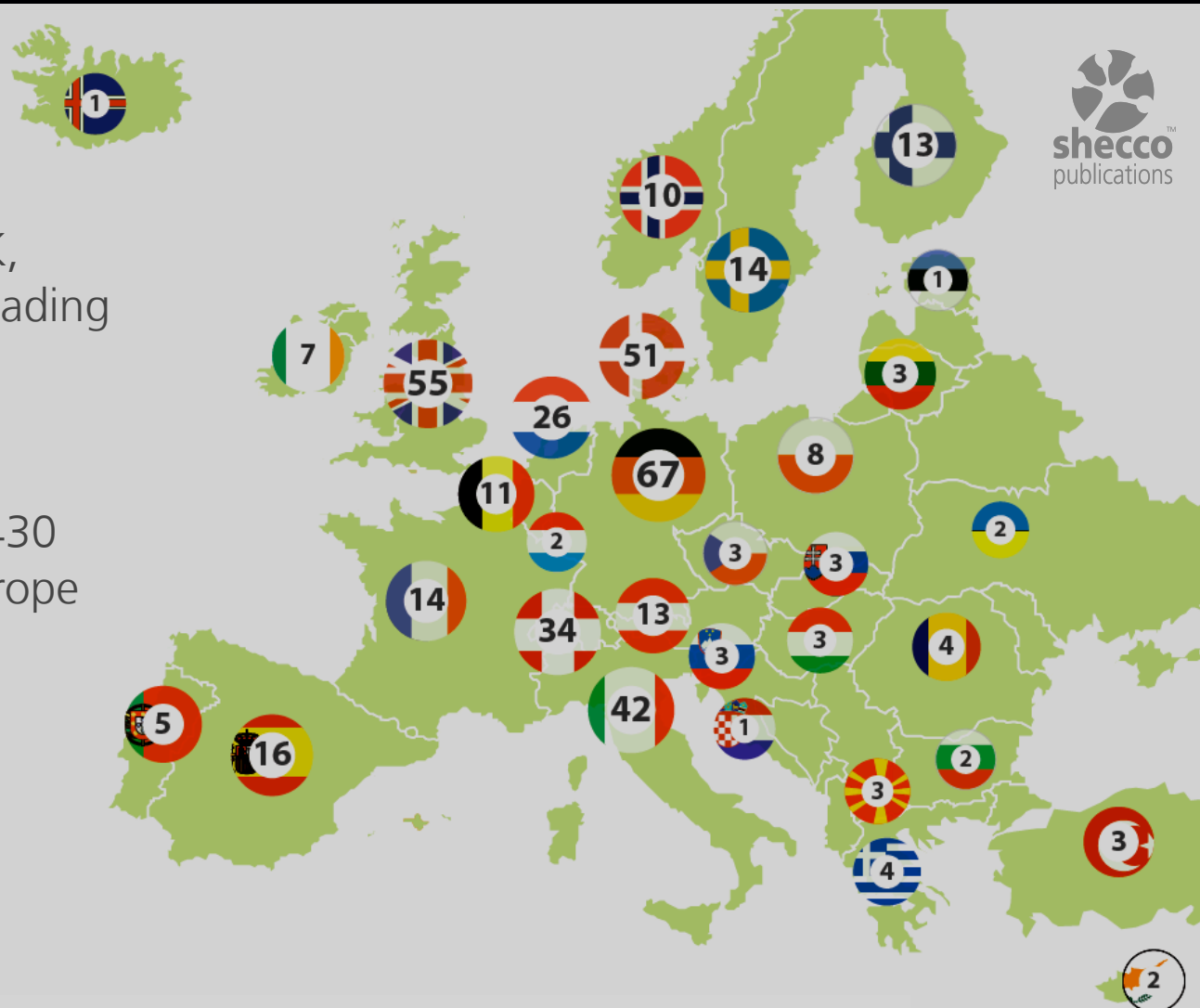


min. 2.7 million HFC-free units worldwide

europa: natural refrigerant industry



- Germany, the UK, Denmark, Italy leading countries in NR technology
- so far counted: 430 companies in Europe



source: shecco, status Nov 2013


europa: commercial availability of NR solutions



REFRIGERATION	TODAY	2015-2020	2020-2025	2025
Domestic Refrigeration	Commercially available	Commercially available	Commercially available	Commercially available
Stand-alone units	Semi commercially available	Commercially available	Commercially available	Commercially available
Condensing units	Semi commercially available	Semi commercially available (2018)	Commercially available	Commercially available
Centralised systems	Semi commercially available	Commercially available	Commercially available	Commercially available
Small industrial refrigeration	Semi commercially available	Commercially available	Commercially available	Commercially available
Large industrial refrigeration	Commercially available	Commercially available	Commercially available	Commercially available
Road transport refrigeration	Not yet commercially available	Not yet commercially available (2017)	Semi commercially available	Commercially available
Container refrigeration	Semi commercially available	Semi commercially available (2017)	Commercially available	Commercially available

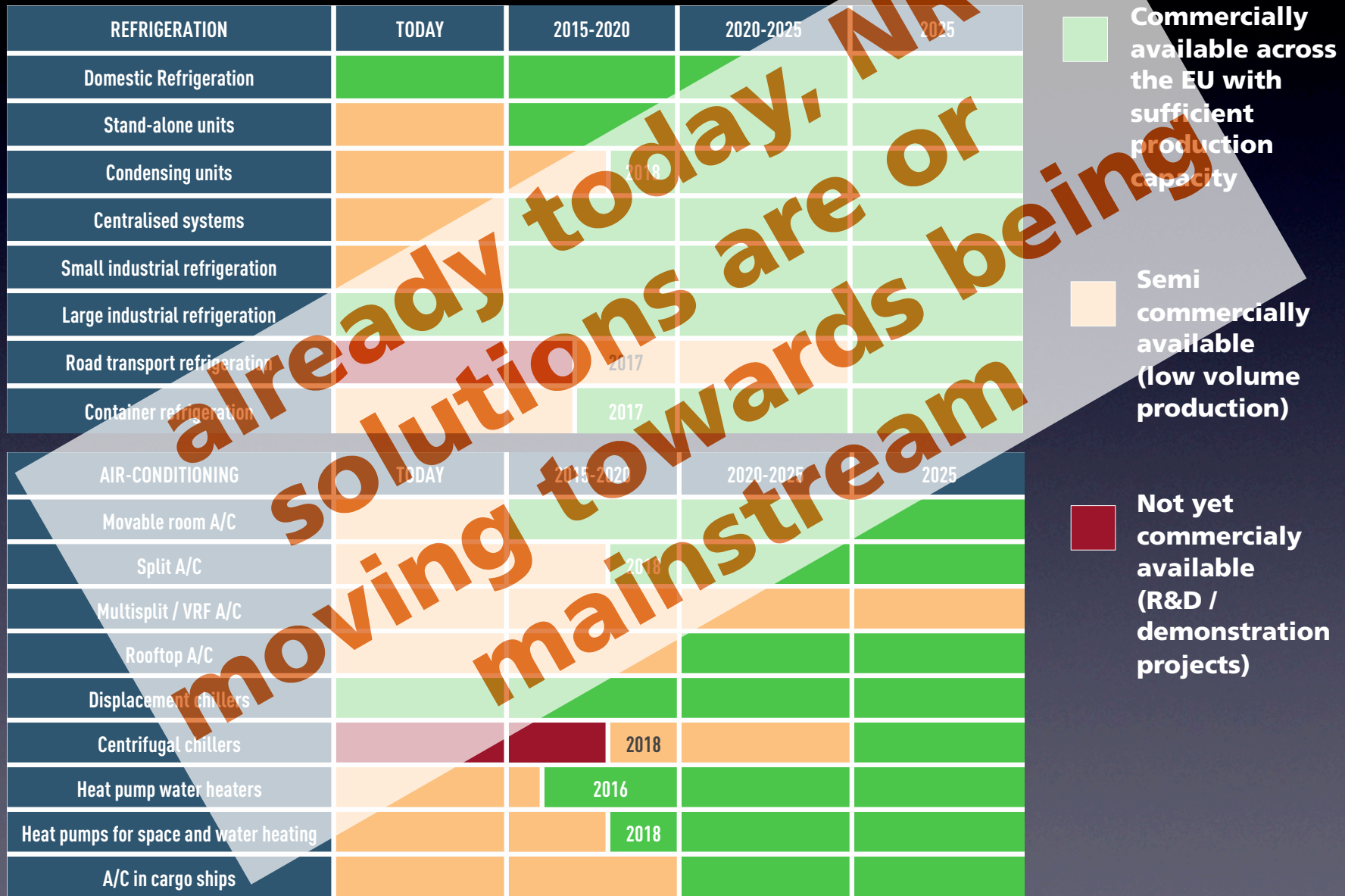
AIR-CONDITIONING	TODAY	2015-2020	2020-2025	2025
Movable room A/C	Semi commercially available	Commercially available	Commercially available	Commercially available
Split A/C	Semi commercially available	Semi commercially available (2018)	Commercially available	Commercially available
Multisplit / VRF A/C	Semi commercially available	Semi commercially available	Semi commercially available	Semi commercially available
Rooftop A/C	Semi commercially available	Semi commercially available	Commercially available	Commercially available
Displacement chillers	Commercially available	Commercially available	Commercially available	Commercially available
Centrifugal chillers	Not yet commercially available	Not yet commercially available (2018)	Semi commercially available	Commercially available
Heat pump water heaters	Semi commercially available	Commercially available (2016)	Commercially available	Commercially available
Heat pumps for space and water heating	Semi commercially available	Semi commercially available (2018)	Commercially available	Commercially available
A/C in cargo ships	Semi commercially available	Semi commercially available	Commercially available	Commercially available

 **Commercially available across the EU with sufficient production capacity**

 **Semi commercially available (low volume production)**

 **Not yet commercially available (R&D / demonstration projects)**

Europe: commercial availability of NR solutions



Europe: commercial availability of NR solutions

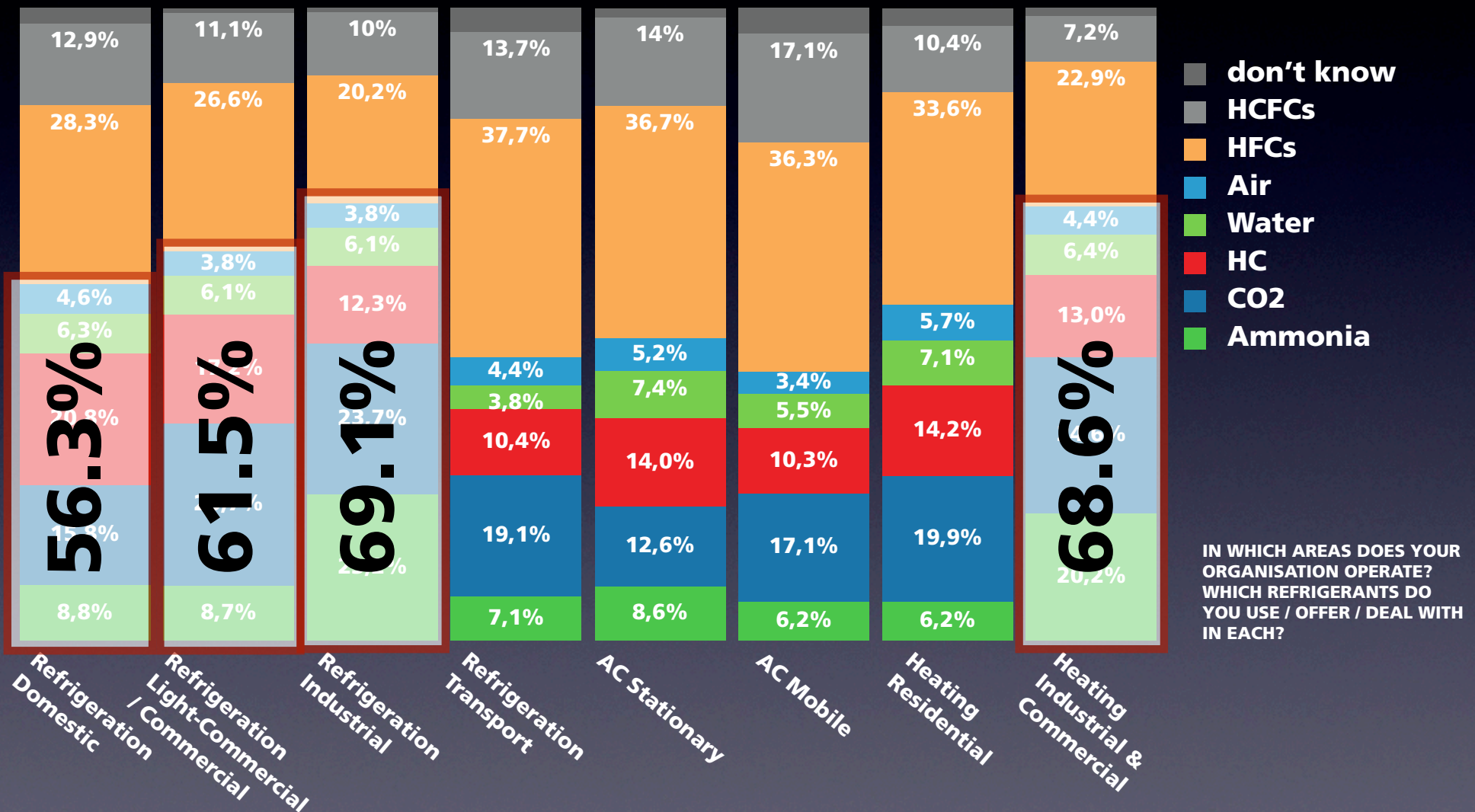


REFRIGERATION	TODAY	2015-2020	2020-2025	2025
Domestic Refrigeration	Commercially available	Commercially available	Commercially available	Commercially available
Stand-alone units	Semi commercially available	Commercially available	Commercially available	Commercially available
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Heat pump water heaters	Semi commercially available	Commercially available	Commercially available	Commercially available
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A/C in cargo ships	Semi commercially available	Commercially available	Commercially available	Commercially available

Industry ready with solutions for most sectors in 2018-2020 in Europe

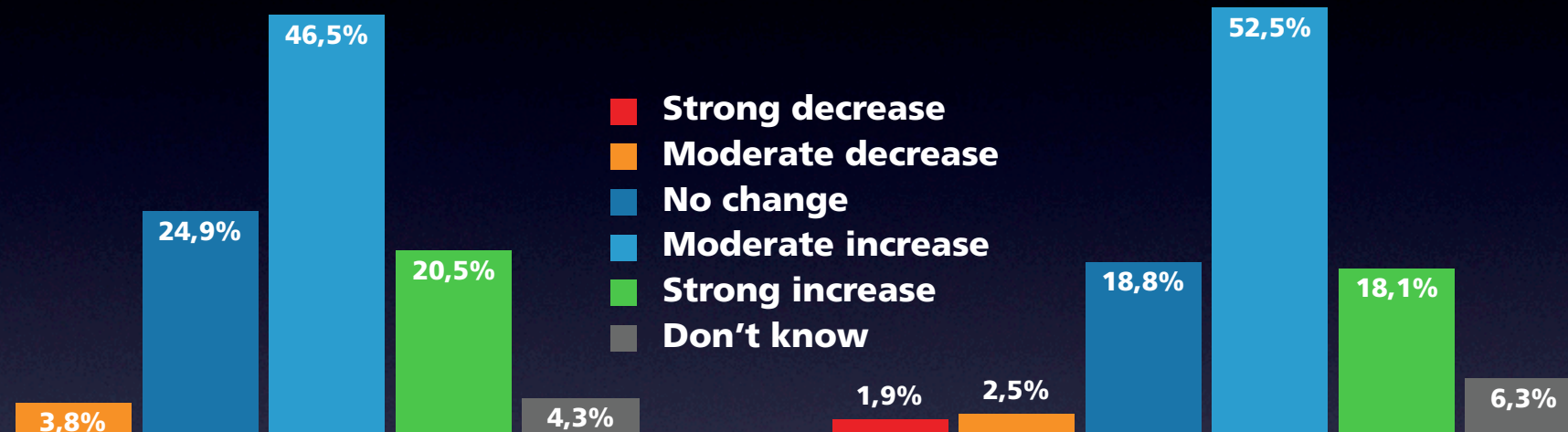
- Commercially available across the EU with sufficient production capacity
- Semi commercially available (low volume production)
- Not yet commercially available (R&D / demonstration projects)

"NR group" in europe: use of natural refrigerants from total, per application



source: shecco survey among 284 European HVAC&R experts offering or using natural refrigerant-based solutions, 2013

“NR group” in europe: change in staff numbers / R&D activities for NR



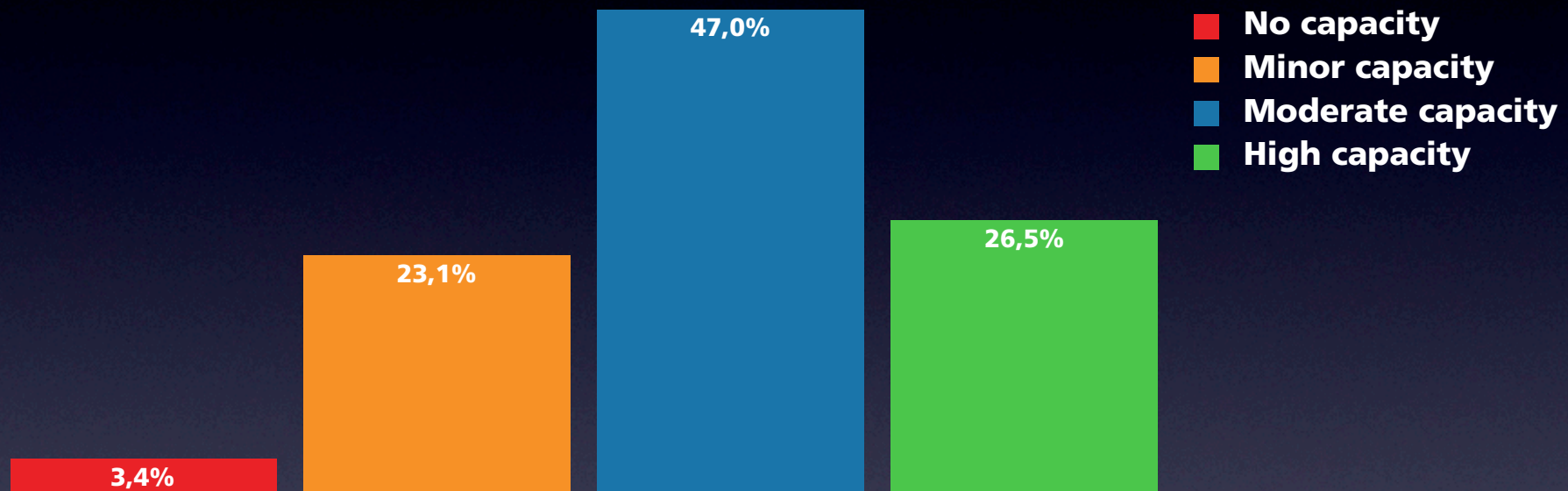
IN YOUR OPINION, HOW WILL THIS SHARE OF STAFF INVOLVED IN NR ACTIVITIES IN YOUR ORGANISATION CHANGE IN THE NEXT 7 YEARS?

IN YOUR OPINION, HOW WILL YOUR ORGANISATION'S R&D ACTIVITIES DEDICATED TO NR CHANGE IN THE NEXT 7 YEARS?

◎ **67% of respondents believe the share of staff involved in NR activities will experience a strong to moderate increase**

◎ **71% of respondents believe NR-related R&D will experience a strong or moderate increase**

north america: leadership potential for natural refrigerants

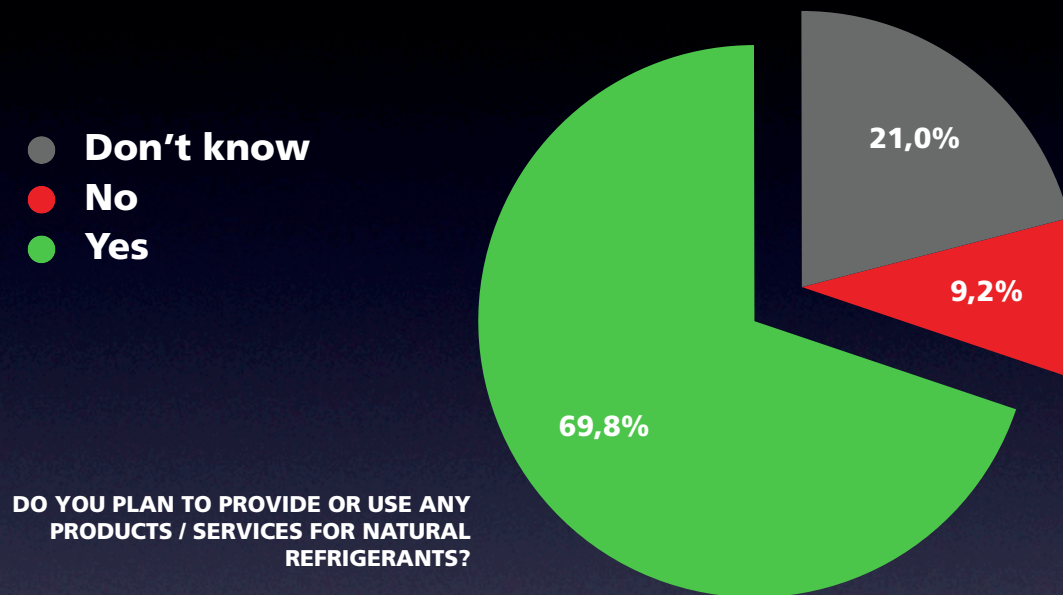


HOW DO YOU EVALUATE THE OVERALL CAPACITY OF THE NORTH AMERICAN INDUSTRY TO BECOME A WORLD LEADER IN NATURAL REFRIGERANT TECHNOLOGY?

- © **nearly half of respondents believe that North America has a “moderate” capacity to become a world leader in natural refrigerant technology, another 1/4 say it is even a “high” capacity**

source: shecco survey among 381 North America HVAC&R experts, 2013

north america: plans to provide solutions for natural refrigerants



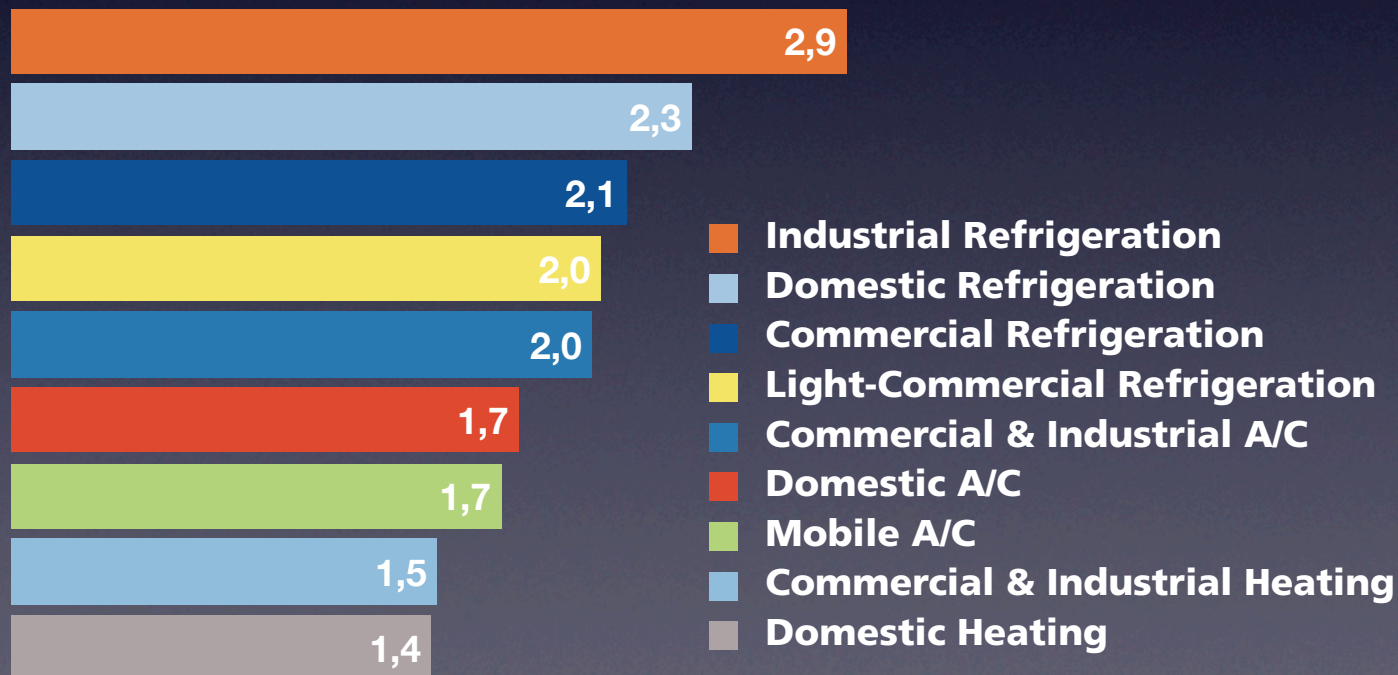
- ⦿ a high majority of respondents - using and not yet using natural refrigerants - is sure to use or provide natural refrigerants in north america
- ⦿ for only those not yet using natural refrigerants, 40% have such plans for the future
- ⦿ our observation: progress is not as fast as we expected

source: shecco survey among 467 North America HVAC&R experts, 2013

developing countries: 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”)



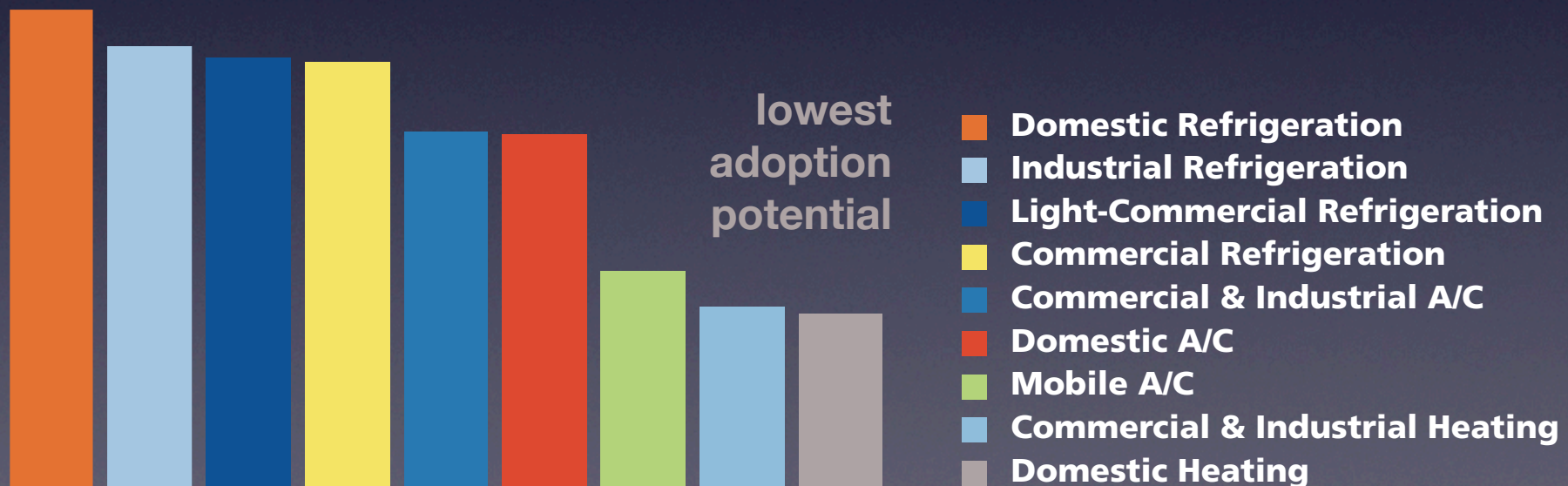
source: shecco / UNIDO survey, scale: 0 (“none”) to 5 (“very high”)

developing countries: 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



developing countries: NR case studies



Featured Case Studies Incentives & Costs Training & Certification
Availability Regulation & Policy Frameworks
Awareness Safety & Technical Standards

barrier addressed

SUCCESS STORIES IN PAKISTAN WITH NATURAL SUBSTANCES



country & continent

World

application refrigerant / foam-blowing agent

CO₂ HC NH₃ H₂O O₂

Almost all industrial refrigeration, cold storage, cargo ships and food industries use ammonia.

- One new R290 line has been added to replace R134a in PEL by Agramkow - 5,000 units of bottle coolers have been sold. One new R600a line for domestic refrigerators has been added by Electrolux - 15,000 units have been sold.

production lines for HC bottle coolers and refrigerators are solid proof for Pakistan's increasing use of natural refrigerants.

<http://www.hydrocarbons21.com/news/view/4331>

<http://www.atmo.org/media.presentation.php?id=220>

key messages / achievements

**UNIDO
ATMOsphere link /
links to further
information**

case: CO₂/NH₃ system in China



DANFOSS: VALVES FOR LANDMARK CO₂ SYSTEM IN ZHANGZI COLD STORAGE



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 CO₂ 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 CO₂ as the refrigerant for this project. Danfoss was subsequently selected as the valve supplier due to its industry leading CO₂ technology, vast experience with CO₂ and high-quality products.

In the newly developed seafood processing centre, the freezing plant utilizes a NH₃/CO₂ cascade system for refrigeration, which lower the NH₃ charge amount by over 90% and limits the NH₃ refrigerant inside of the refrigeration control room, fully satisfying the safety requirements of Zhangzi Island group.

The cold storage plant utilizes a CO₂ 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 CO₂ 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 NH₃/CO₂ 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 NH₃/CO₂ cascade system for refrigeration. This has lowered the NH₃ charge amount by over 90% and limits the NH₃ refrigerant inside of the refrigeration control room. The cold storage plant utilizes a CO₂ 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 CO₂ solutions extensively throughout the entire system, raising safety and reliability while reducing welding time by 80%.



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<http://www.stmo.org/media.presentation.php?id=225>

CASE STUDY: DANFOSS

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CASE STUDY: DANFOSS

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- major milestone in China
- Zhangzi seafood processing plant uses cascade refrigeration system and CO₂ 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 CO₂-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 NH₃ 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 NH₃ and CO₂.

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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CASE STUDY: DSI

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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

CASE STUDY: DSI

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case: CO₂ 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 CO₂ 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 CO₂ 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 "CO₂ HEAT PUMPS ARE GROWING IN POPULARITY IN CHINA". Below the header are two icons: a flame in a circle and a CO₂ 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 quote box on the right side contains a testimonial. At the bottom, there is a URL: <http://www.r744.com/news/view/3424>.

CO₂ HEAT PUMPS ARE GROWING IN POPULARITY IN CHINA

The CO₂ 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 CO₂ heat pumps were installed in a 3000 m² 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 CO₂ heat pump water heater was installed in October 2011 in the Wuhan University of China to provide hot drinking water. The combined CO₂ 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 CO₂ heat pumps are used in space and water heating in China. A group of domestic manufacturers have emerged. Today there are more than 30 CO₂ heat pump installations across the country.

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

cases around the world



Zimbabwe, Angola, Tunisia:
"plug-and-play" ammonia chillers achieve carbon footprint reduction of 12 tonnes CO₂/year, compared to R134a

Pakistan: 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: R290 room 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 or will soon become available. globally active suppliers already today deliver their products worldwide and constantly innovate. local initiatives are increasing.

main messages



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

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<http://www.R718.com>

ATMOsphere conferences, side-events & network meetings:

<http://www.ATMO.org>

GUIDES (Europe 2012; North America 2013; CO₂/NH₃ industrial refrigeration 2013; GUIDE UNIDO 2013) + ATMOsphere Summary Reports

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