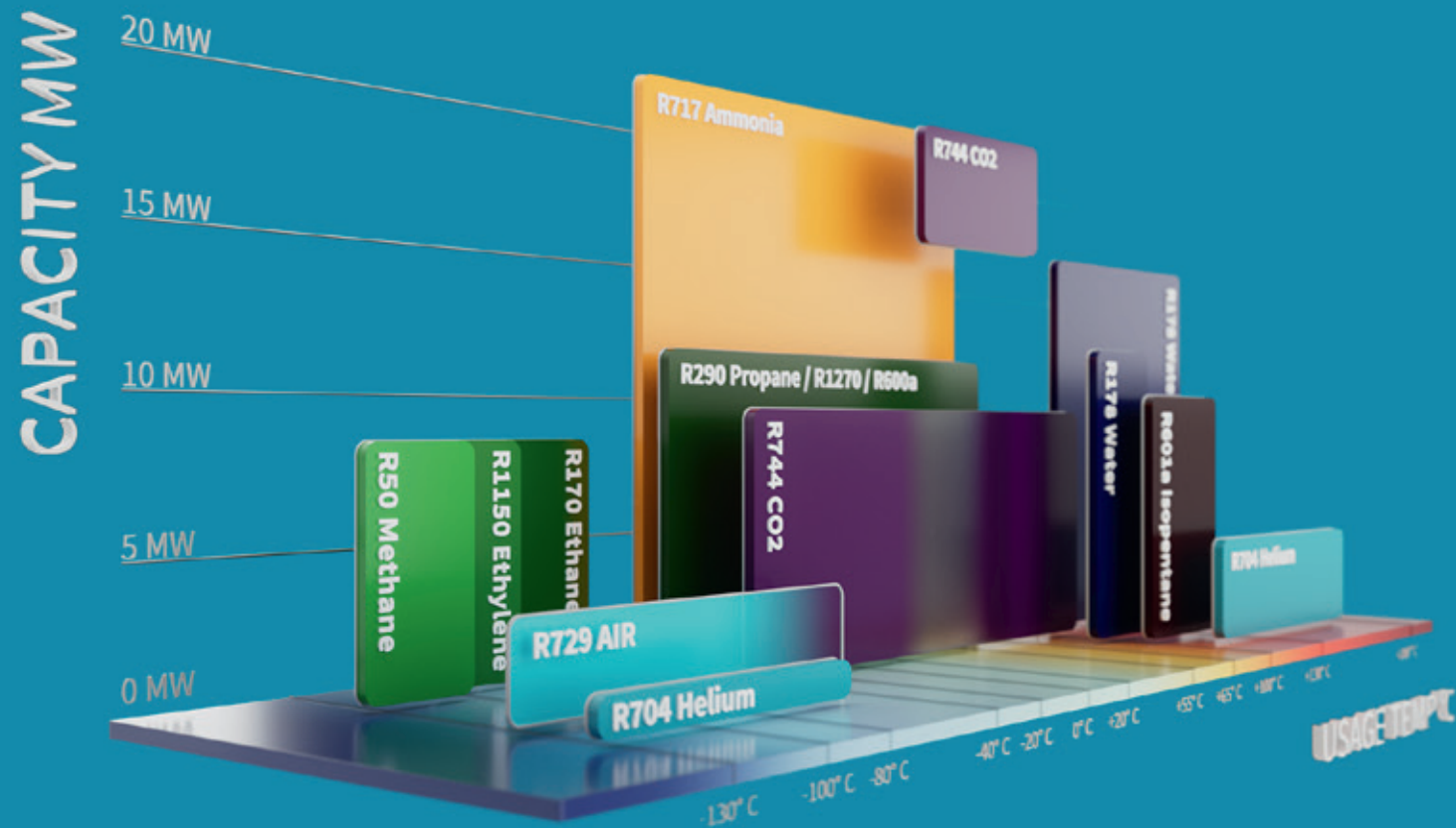




Choosing the Best Natural Refrigerant for Your Application

A Guide for the Refrigeration, Air-Conditioning and Heat Pump Sector

PROCESS COOLING AND HEATING ➤

COOLING AND HEATING FOR COMFORT ➤

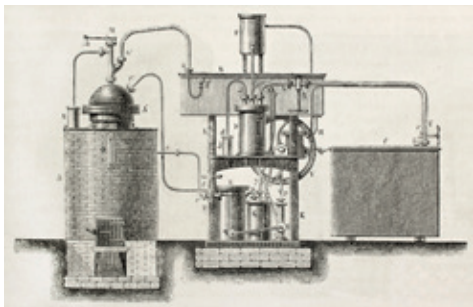
STORAGE AND PRESERVATION ➤



Contents

3	Introduction
4	Why Opt for Natural Refrigerants
6	Overview Natural Refrigerants
8	Application Selection Guide
10	Regulatory Framework
14	Recommendations & Conclusion
16	Further Reading and Reference

Introduction



01



02

Purpose and Audience

This guide provides practical information for system builders, consultants, operators, and end users in the refrigeration, air conditioning, and heat pump (RACHP) sector. It serves as a quick reference for selecting the optimal natural refrigerant for specific applications, with links to detailed eurammon resources for further reading.

Why This Guide?

The refrigeration industry is undergoing a fundamental transformation. After decades of using synthetic refrigerants - from CFCs to HCFCs to HFCs - it is increasing the use of natural refrigerants. So the industry is returning to where it began: natural refrigerants.

History of refrigeration

– the role of natural refrigerants

The roots of modern refrigeration lie in natural substances: from the very first mechanical refrigeration experiments in the 18th century, engineers and inventors turned to materials found in nature to produce cold.

In 1805, Oliver Evans conceived the first closed-cycle refrigeration machine, and Jacob Perkins built on this in 1835 to patent the first practical vapour-compression refrigerator, which laid the engineering foundations that the entire industry still rests on.

Throughout the 19th century, inventors worked with several substances: ammonia (R717), carbon dioxide (R744), methyl chloride (R40), sulphur dioxide (R764), and hydrocarbons were all explored and deployed. Carl von Linde's groundbreaking ammonia compressor of 1877 established ammonia as the workhorse of industrial refrigeration.

By the late 1920s, roughly a quarter of all smaller refrigeration systems ran on a variety of natural and flammable refrigerants, while ammonia dominated more than 90% of large commercial and industrial plants. The shift came in the 1930s when halocarbon refrigerants (CFCs) were commercialised and gradually replaced natural refrigerants - not primarily because of fire risk, but to address toxicity concerns and the commercial appeal of seemingly simpler synthetic fluids. This displacement was never complete, and it ultimately carried far graver consequences: ozone depletion and accelerating climate change.

The Montreal Protocol, signed in 1987, forced a reckoning - and with it a re-emergence of natural refrigerants, catalysed by campaigns such as Greenpeace's "Greenfreeze" initiative, which drove virtually all European domestic appliance manufacturers back to isobutane (R600a) in the early 1990s.

Today, driven by environmental regulations and climate commitments, natural refrigerants are the future-proof refrigerant choice for sustainable heating and cooling.

01. Industrial Cooling Illustration
02. Rows of large commercial HVAC systems



List of Acronyms: A-I

ACRONYM	MEANING
AC	Air Conditioning
ACHP	Air Conditioning and Heat Pumps
ATEX	Atmosphères explosibles (explosive atmospheres) – EU Directives 1999/92/EC and 2014/34/EU
CFC	Chlorofluorocarbon
CO ₂ eq	Carbon dioxide equivalent
EN	European Standard (Europäische Norm)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMP	Good Manufacturing Practice
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
IEA	International Energy Agency
IEC	International Electrotechnical Commission

List of Acronyms: I-U

ACRONYM	MEANING
IIAR	International Institute of All-Natural Refrigeration
IIR	International Institute of Refrigeration (Institut International du Froid)
ISO	International Organization for Standardization
NIST	National Institute of Standards and Technology
ODP	Ozone Depletion Potential
OSH	Occupational Safety and Health
PED	Pressure Equipment Directive (Directive 2014/68/EU)
PFAS	Per- and polyfluoroalkyl substances
RACHP	Refrigeration, Air Conditioning and Heat Pumps
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (Regulation (EC) No 1907/2006)
TEAP	Technology and Economic Assessment Panel
TEWI	Total Equivalent Warming Impact
TFA	Trifluoroacetic acid
UNEP	United Nations Environment Programme

Why Opt for Natural Refrigerants



01



02

01. Industrial Refrigeration System
02. Natural Refrigerants

Natural refrigerants are substances that occur in nature and are used in refrigeration and air conditioning systems, and in heat pumps.

Unlike synthetic refrigerants, which can have harmful effects on the environment, natural refrigerants are environmentally acceptable and contribute to a sustainable operation of RACHP equipment.

They have negligible global warming potential (GWP), zero ozone depletion potential (ODP) and are no PFAS chemicals. Therefore, the use of natural refrigerants enables compliance with GWP-, PFAS- and ODP- based regulations, such as the F-gas regulation, the Kigali-Amendment and the upcoming PFAS restriction under REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals).

The “Natural 5” include Ammonia, Carbon Dioxide, Hydrocarbons, Water and Air. The RACHP sector contributes to climate change through direct emissions from refrigerant leakage during operation, maintenance, and end-of-life of appliances, and indirect emissions from energy consumption during manufacturing, operation, recycling and/or disposal processes.

By using natural refrigerants, CO₂eq direct emissions caused by refrigerant leakage are eliminated.

Indirect emissions from energy consumption depend on the energy source: fossil-fuel-based electricity generates significantly higher CO₂eq emissions than electricity from renewable sources. The use of natural refrigerants allows negligible GWP and also enables the reduction of indirect emissions.

The phase-out of refrigerants under the F-Gas Regulation typically leads to significant price increases prior to the bans taking effect, which does not affect natural refrigerants.

They are widely available commodity substances, and in most applications they deliver equal or better efficiency, which lowers the indirect emissions of the total equivalent warming impact (TEWI) of a modern RACHP system.

Natural Refrigerants at a Glance: Three Key Advantages:



Negligible GWP, zero ODP

Natural refrigerants have negligible GWP, zero ODP, and contain no PFAS chemicals.



Regulatory Compliance

Their use ensures compliance with the F-Gas Regulation, Kigali Amendment and upcoming PFAS restrictions under REACH.



Lower TEWI

Eliminating leakage emissions and offering equal or better efficiency reduces the TEWI of RACHP systems.

Overview of Natural Refrigerants

The following natural refrigerants can be used across all refrigeration, air-conditioning and heat pump applications:

Hydrocarbons

– Including R50 (Methane), R1150 (Ethylene), R1270 (Propylene), R170 (Ethane), R290 (Propane), R600 (Butane), R600a (Isobutane) and R601a (Isopentane). Applications range from domestic and light commercial refrigeration, air-conditioning and heat pumps, to low-temperature and ultra-low temperature industrial systems

R744 (Carbon Dioxide)

– Characterised by a low GWP and high working pressures with therefore high compactness; Mainly used in commercial refrigeration and industrial heat pumps

R717 (Ammonia)

– Used primarily in industrial refrigeration and large-scale heat pumps; also applied in some commercial systems

R718 (Water)

– A safe and non-toxic refrigerant, primarily used in high temperature heat pumps

R729 (Air)

– Safe and non-toxic, primarily used for low temperature cryogenic refrigeration

Others

– Noble gases, such as R704 (helium), for specialized applications



R50, R1150,
R1270, R170,
R290, R600,
R600a and
R601a

Hydrocarbones



R718

Water



R729

Air



R744

Carbon Dioxide



R704

Helium



R717

Ammonia

Natural refrigerants cover the entire RACHP spectrum.

Figure 1 plots the two parameters that determine the choice of refrigerant for a specific system - namely, the operating temperature range and system capacity - for each of the key natural refrigerants.

Together, they cover a temperature range of approximately -130°C to +200°C, with no gaps. Furthermore, they span system capacities ranging from less than a kW for 'plug-in' equipment to over 20 MW for industrial installations.

Across much of this range, the application areas of different refrigerants overlap, meaning that multiple options are technically feasible.

The final choice is then based on site-specific criteria — such as efficiency, safety class, charge limits, constraints regarding the plant room and location, and component availability and costs - as outlined on pages 18ff

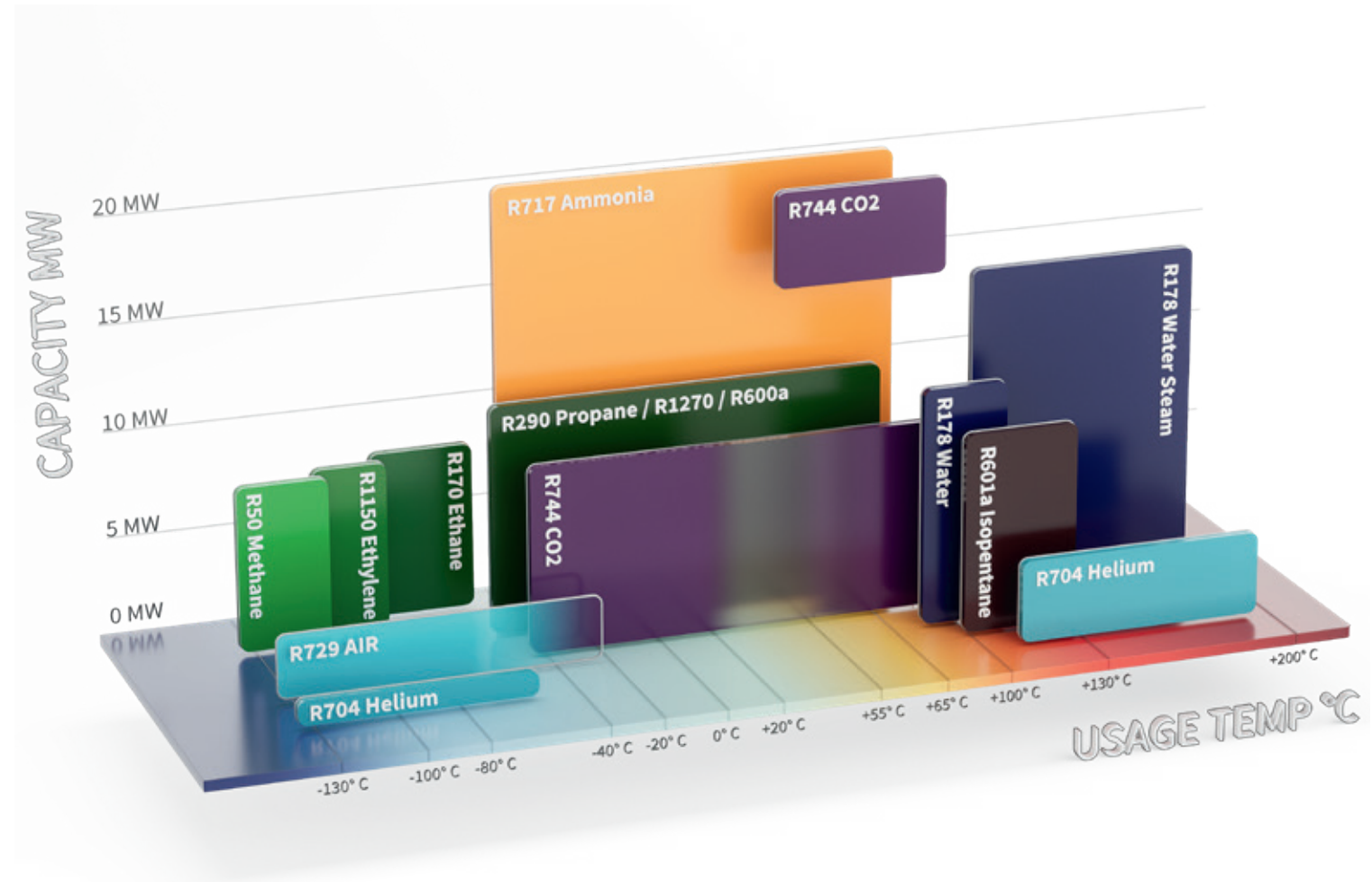


Figure 1a: Practical application ranges for natural refrigerants by temperature and system capacity Source: Eurammon e.V.

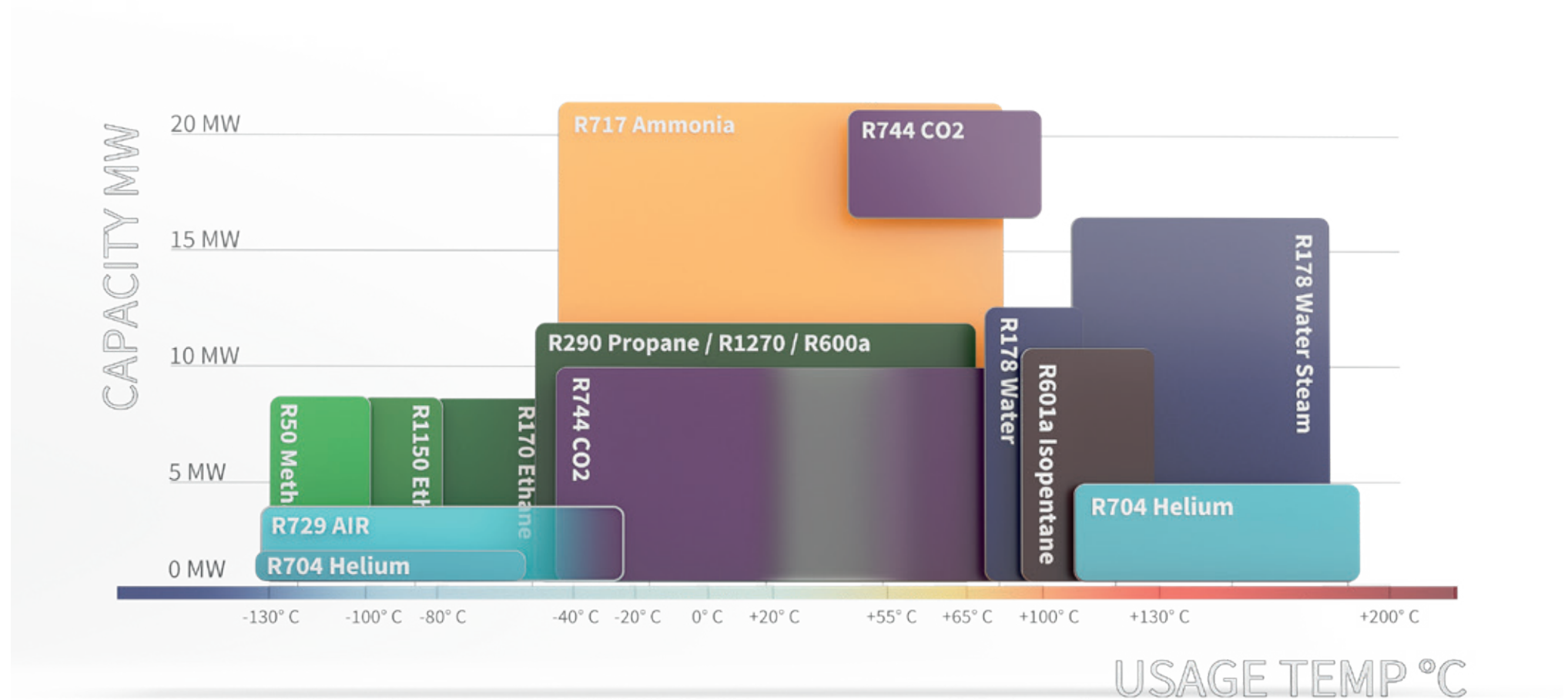
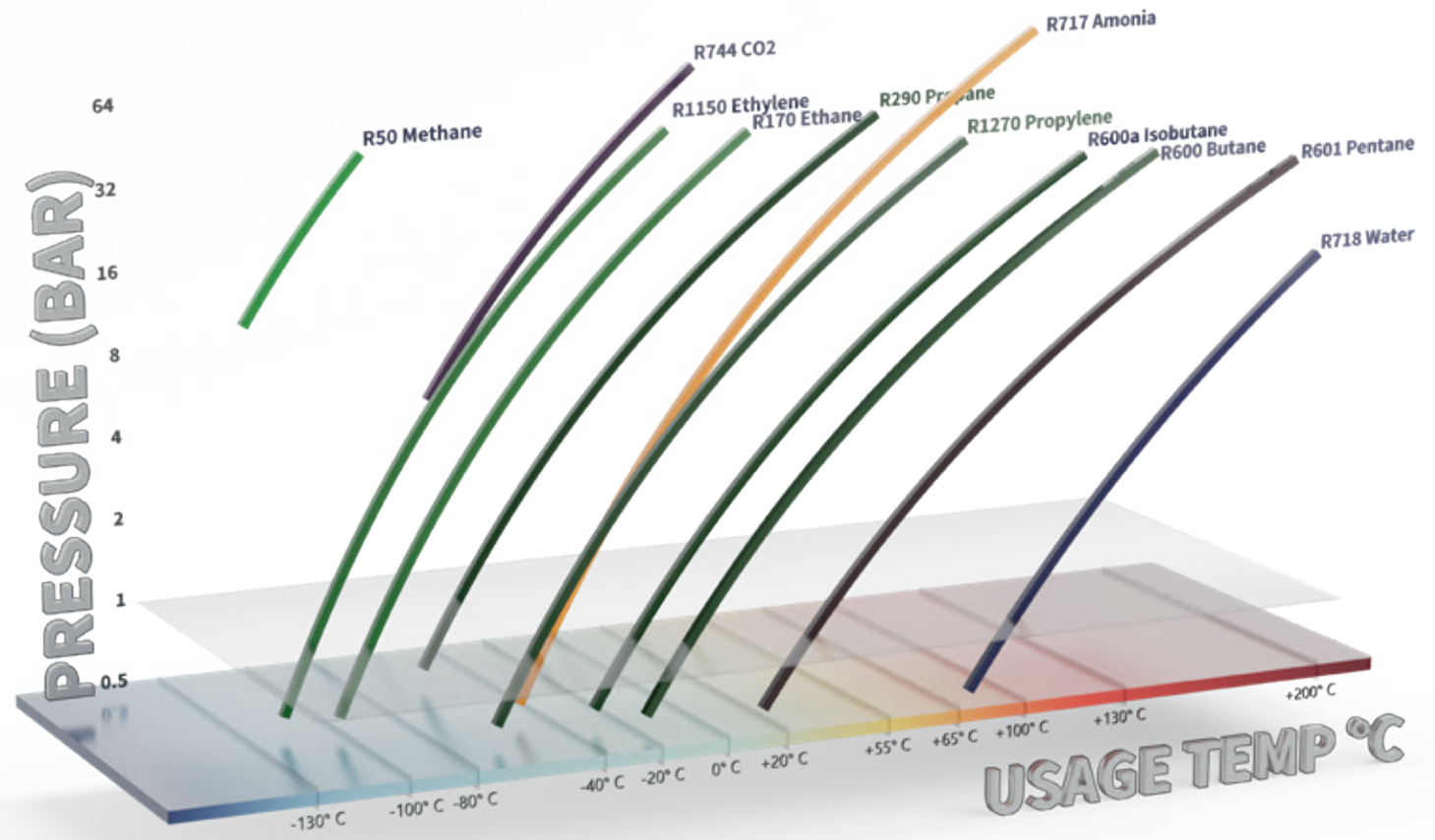


Figure 1b: Different perspective - Figure 1a

Pressure Level and System Design

Temperature and capacity for the application narrow the choice for a refrigerant. The application temperature affects the required refrigerant temperatures and, consequently, their vapor pressures. Figure 2 shows the saturation pressure each natural refrigerant demands across its operating range, and so translates the selection made in Figure 1 into consequences for components, materials and design effort. The curve of each refrigerant gives the low-side pressure at the evaporating temperature and the high-side pressure at the condensing temperature.

Two thresholds matter. Operation below atmospheric pressure, approximately 1 bar(a), means that any leak draws air and moisture into the system rather than releasing refrigerant outwards. Non-condensable gases then collect in the condenser and raise the condensing pressure, cutting efficiency, while moisture corrodes components and degrades the oil. This calls for specific measures: welded rather than mechanical joints, purge equipment to remove non-condensables, driers, and systematic leak and vacuum testing. R718 operates this way across its entire range, which is one reason it remains confined to specific high-temperature and absorption applications.



Operating Limits of Conventional Vapour-Compression Refrigeration

At pressures above roughly 30 bar(a), system design becomes more complex and costly because components must be rated for the higher pressure - but the same high pressure makes the vapour dense, so R744 systems are markedly more compact than equivalent systems using other refrigerants.

The pressure level does not rule a refrigerant out, it determines considerations to be taken into account for system design and components.

This diagram illustrates the pressure-temperature relationships that help define the operating limits of conventional vapour-compression systems using natural refrigerants.

Saturation pressure is plotted on a logarithmic scale against temperature. The curves indicate the evaporating and condensing pressures at the corresponding temperatures.

Air (R729) and helium (R704) are not shown, as they are used in gas refrigeration cycles without a phase change.

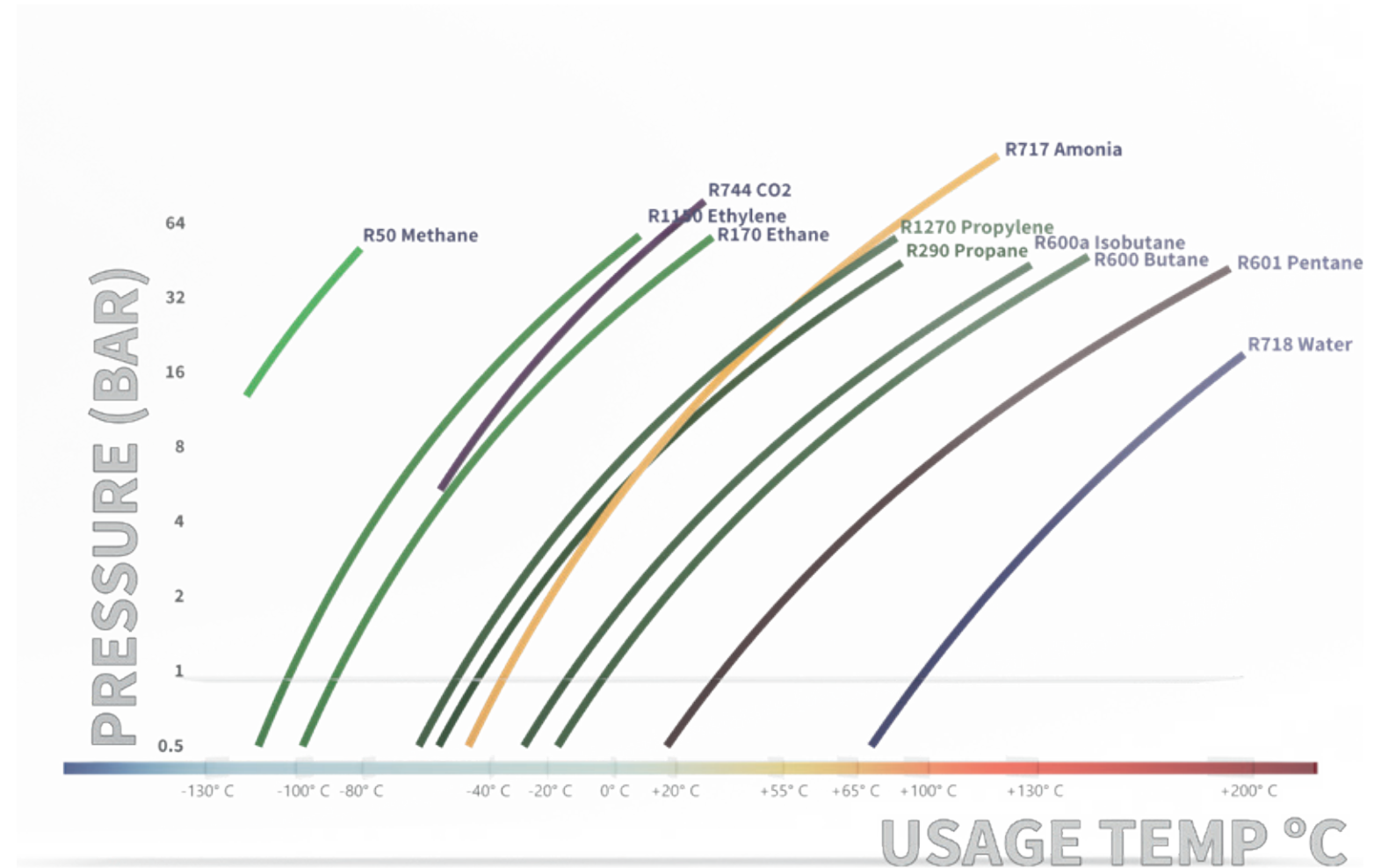


Figure 2b: Different perspective - Figure 2a

Below Tables Summarize the Characteristics of the Most Common Natural Refrigerants:



R50, R1150, R1270,
R170, R290, R600,
R600a and R601a

Hydrocarbons

Hydrocarbon-based blends are used in selected RACHP applications to keep ultra-low GWP while tuning performance characteristics (for example pressure level, capacity, or retrofit behavior) for specific system designs.

Further reading: eurammon Factsheet Hydrocarbons

Hydrocarbons	GWP 100 ¹	Typical applications
R50	27.9	Ultra low temperature application down to -130°C
R170	0.437	Low temperature refrigeration down to -80°C, petrochemical
R290	0.02	Split ACs, commercial refrigeration, heat pumps
R600	0.0006	Refrigeration, blend component
R600a	0	Domestic refrigerators, industrial heat pumps
R601a	0	Heat pumps, foam blowing
R1150	4	Cryogenic applications, cascade systems
R1270	0	Industrial chillers, process cooling

Properties	For all hydrocarbons
ODP	0
Safety class ²	A3 (flammable)
Thermo/performance	Excellent thermodynamic properties; compatible with standard refrigeration oils
Safety	Flammability managed through charge limits and safety design; well-established standards (IEC 60335-2-24, IEC 60335-2-89) [1]
Historical use	In early refrigeration systems in the late 19th and early 20th centuries

A3 Highly flammable

Factsheet:
Hydrocarbons





R744

Carbon Dioxide

Further reading: eurammon Information Paper: Carbon Dioxide R744

R744
Chemical formula
GWP
ODP
Safety class ²
Typical applications
Thermo/performance
Safety
Historical use

Carbon dioxide
CO2
1
0
A1 (lower toxicity, non-flammable)
Supermarket refrigeration, transport cooling, heat pumps, cascade systems, mobile air-conditioning
Works efficiently in low temperature cascade systems with R717; excellent for heat pump applications with high temperature lifts
Ideal for public spaces; high operating pressures require specialised components
By the 1930s, approximately 80% of marine refrigeration used R744

A1

Non-flammable

² According to ISO 817.

Information Paper:
Carbon Dioxide R744



R717

Ammonia

Further reading:
eurammon Information Paper: Ammonia R717

R717
Chemical formula
GWP
ODP
Safety class ²
Typical applications
Thermo/performance
Safety
Historical use

Ammonia
NH ₃
0
0
B2L (toxic, low flammability)
Industrial refrigeration, cold storage, ice rinks, heat pumps
Excellent thermodynamic properties – highest efficiency among common refrigerants
Self-alarming odour allows immediate leak detection (threshold 5–50 ppm); lighter than air (rapid dispersion)
Over 150 years of proven industrial use; in the 19th century R717 was considered the backbone of the food industry

B2L Toxic + mildly flammable

² According to ISO 817.

Factsheet:
 Ammonia - a natural refrigerant



R718

Water

Further reading:
eurammon Information Paper: Water R718

R718
Chemical formula
GWP
ODP
Safety class ²
Typical applications
Thermo/performance
Safety
Historical use

Water
H ₂ O
0
0
A1 (lower toxicity, non-flammable)
Evaporative cooling, absorption chillers, high-temperature heat pumps
High latent heat of vaporisation
No toxicity or flammability concerns
Used as a refrigerant for thousands of years

A1

Non-flammable

² According to ISO 817.



R729

Air

Further reading:
eurammon Information Paper: Air R729

R729
Chemical formula
GWP
ODP
Safety class ²
Typical applications
Thermo/performance
Safety
Historical use

Air
Mixture (N ₂ /O ₂)
0
0
A1 (lower toxicity, non-flammable)
Cryogenic applications, aircraft cabin cooling, pharmaceutical storage, low temperature cryogenic refrigeration, grinding, hardening of metals and deburring of plastics; freeze-drying, biological and medical storage
Ideal for ultra-low temperature applications (-40°C and below)
No toxicity or flammability concerns
In early vapour-compression or air-cycle designs in the 19th and early 20th centuries; aviation

A1

Non-flammable

² According to ISO 817.

R704

Helium

Further reading:
eurammon Information Paper: Helium R704

R704
Chemical formula
GWP
ODP
Safety class ²
Typical applications
Thermo/performance
Safety
Historical use

Helium
He
0
0
A1 (lower toxicity, non-flammable)
High-temperature heat pumps
Lowest boiling point of all substances (4.2 K / -269°C); enables cooling close to absolute zero
Non-toxic and non-flammable; risk of asphyxiation in enclosed spaces due to oxygen displacement
First liquefied in 1908 by Heike Kamerlingh Onnes; enabled the discovery of superconductivity in 1911

A1

Non-flammable

² According to ISO 817.

Application Selection Guide

Natural refrigerants can cover all RACHP applications. The figures in this section support refrigerant selection at three levels of detail: Figure 3 shows the established options for each temperature range, Figure 4 sets out the selection criteria in sequence, and Figures 5a–5c detail the technologies and documented installations for each application area.

Refrigerant options by temperature range

Figure 3 divides the RACHP sector into four areas by the temperature level at which they work: ultra-low temperatures, refrigeration and air conditioning for cooling, and heat pumps for heat delivery. It shows which natural refrigerants are established in each temperature range. Most refrigerants are suitable for more than one application.

Natural Refrigerant Options by Typical Application

Natural Refrigerant	Ultra-low temperatures	Refrigeration	Air conditioning	Heat Pumps
R1150				
R170				
R1270				
R290				
R600				
R600a				
R601a				
R717				
R718				
R729				
R744				

Figure 3: Natural refrigerant options by application temperature range. Source: eurammon e.V.

Refrigerant Selection Decision Points

Refrigerant selection involves multiple interdependent criteria. Figure 4 structures the process into sequential decision points, allowing operators, planners and end users to narrow the options to the most suitable natural refrigerant for a specific system. Whichever refrigerant is selected, the overall system design must fit the purpose.

Step 1: Determine temperature requirements	Step 2: Evaluate cooling & heating capacity	Step 3: Consider system design	Step 4: Assess local market conditions
a) Above 100°C → Consider R718, R717, R744 b) 0°C to 100°C → Consider R290, R717, R744, R600a c) -40°C to 0°C → Consider R717, R744, R290 d) Below -40°C → Consider R717, R744 (cascade), R729, R170, R1150	a) Small → R290, R600a, R744 b) Medium → R290, R744, R717 c) Large → R717, R717/R744 cascade d) More details: see Figure 5	a) Direct expansion → All natural refrigerants possible b) Indirect/secondary loop → Reduces refrigerant charge and enables the use of efficient flooded-ammonia systems in more applications. c) Cascade systems → R717/R744 combination for wide temperature ranges d) System design needs to be adapted to outer conditions, for example outside temperature ranges etc	a) Availability of compressors & components b) Local supply of refrigerants c) Competence of local technicians & designers d) Efficiency for particular temperature lift and system design

Figure 4: Natural refrigerant selection for RACHP applications. Source: eurammon e.V.

Established Technologies and Practice Examples

The pages below set out the selection sequence for the three application areas covering the RACHP sector in more detail:

cold rooms, process cooling with a secondary fluid and heat pumps.

Read from left to right, each tree addresses application area, temperature range, and capacity, which leads to the natural refrigerants established for that area, their safety classification, the corresponding technology, and, where available, a documented eurammon case study.

Where a branch offers several refrigerants, all are technically proven; the choice between them is made on charge limits, machinery-room constraints, heat recovery potential and cost.

Eurammon's case study library documents installations across Europe and beyond. It provides operators, planners, and system designers with documented performance data, system configurations, and lessons learned. Links to practice examples for all application areas are included in Figure 5 below. An empty case-study field means no case study has yet been published for that branch, not that the technology is unproven.



Application

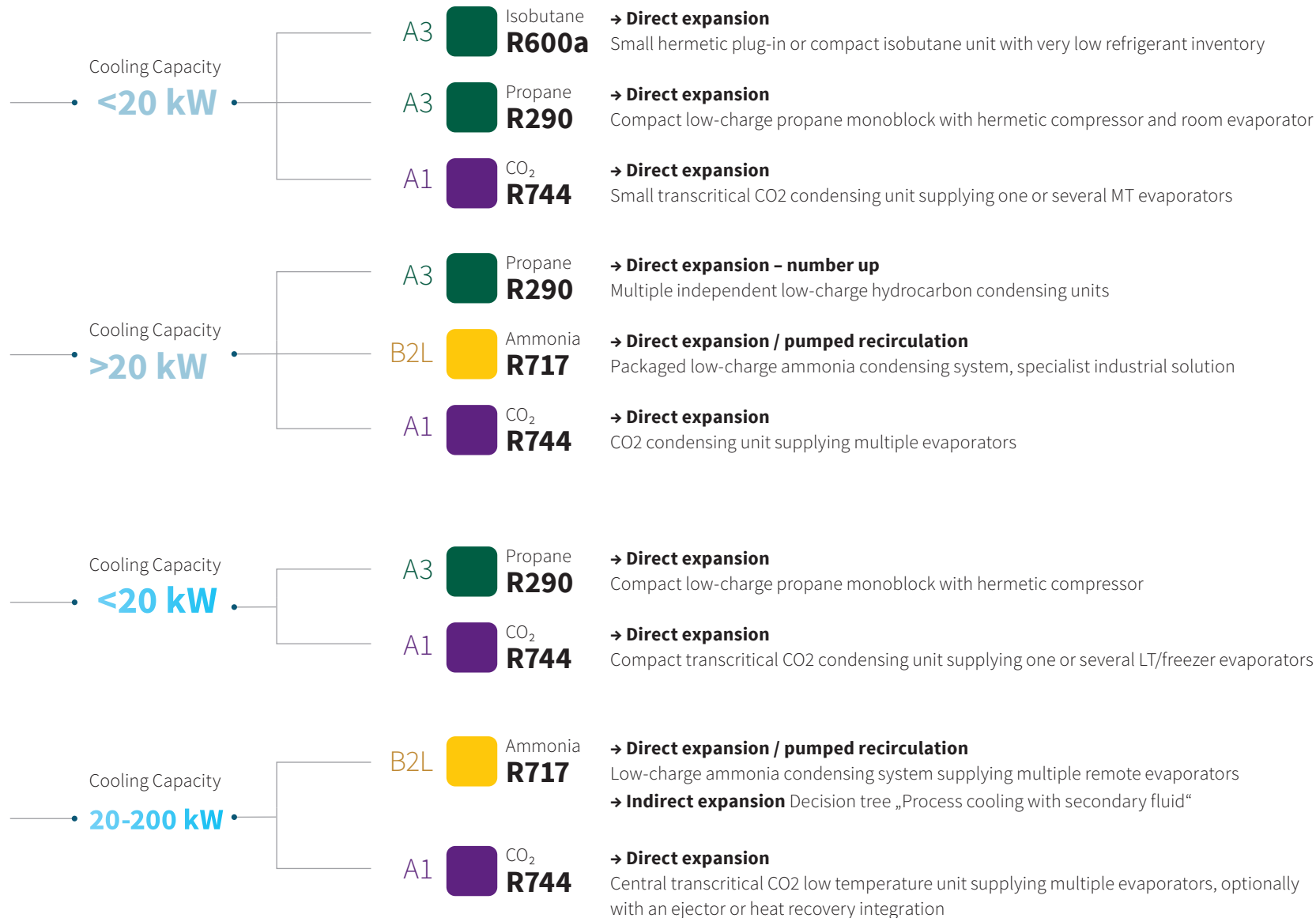
Cold rooms 1/2

Temperature Range

+15 °C to 0 °C**Chilled rooms**

Temperature Range

0 °C to -40 °C**Freezer rooms**Temperature Range **-40 °C to -160 °C** on pages 24-25:**Deep cold**



Case Study: Eco-friendly
CO₂ Refrigeration Plant for
S-Market, Finland



Case Study:
RefoBlast Vienna



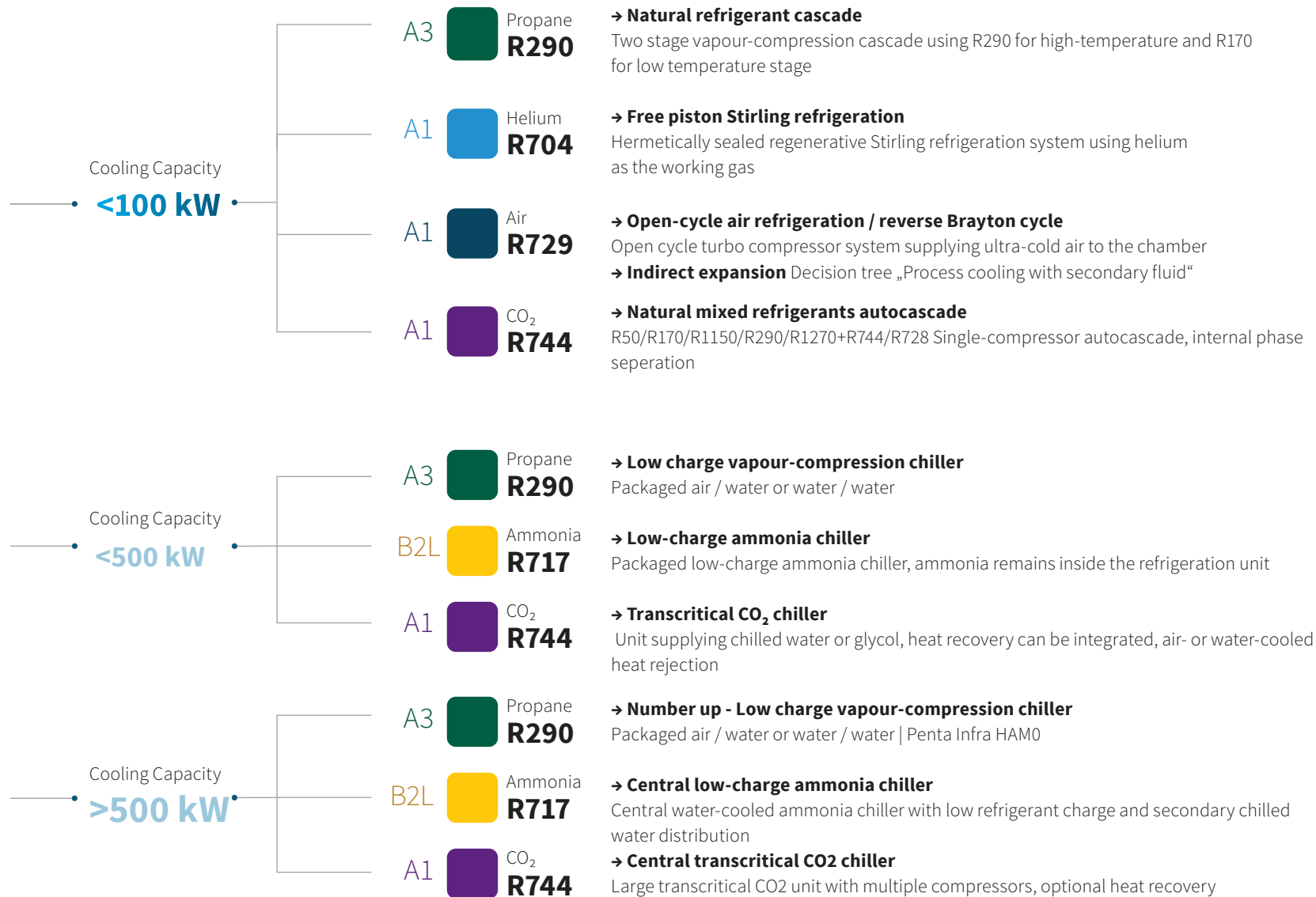
Case Study:
Fernhurst Australia



Case Study:
Super Best Supermarket

Application
Cold rooms 2/2  —  Temperature Range
-40 °C to -160 °C  **Deep cold**

Application
Process cooling 1/2  —  Temperature Range
20 °C to 4 °C  **Medium temperature**



Case Study: Supermarket
Integral System



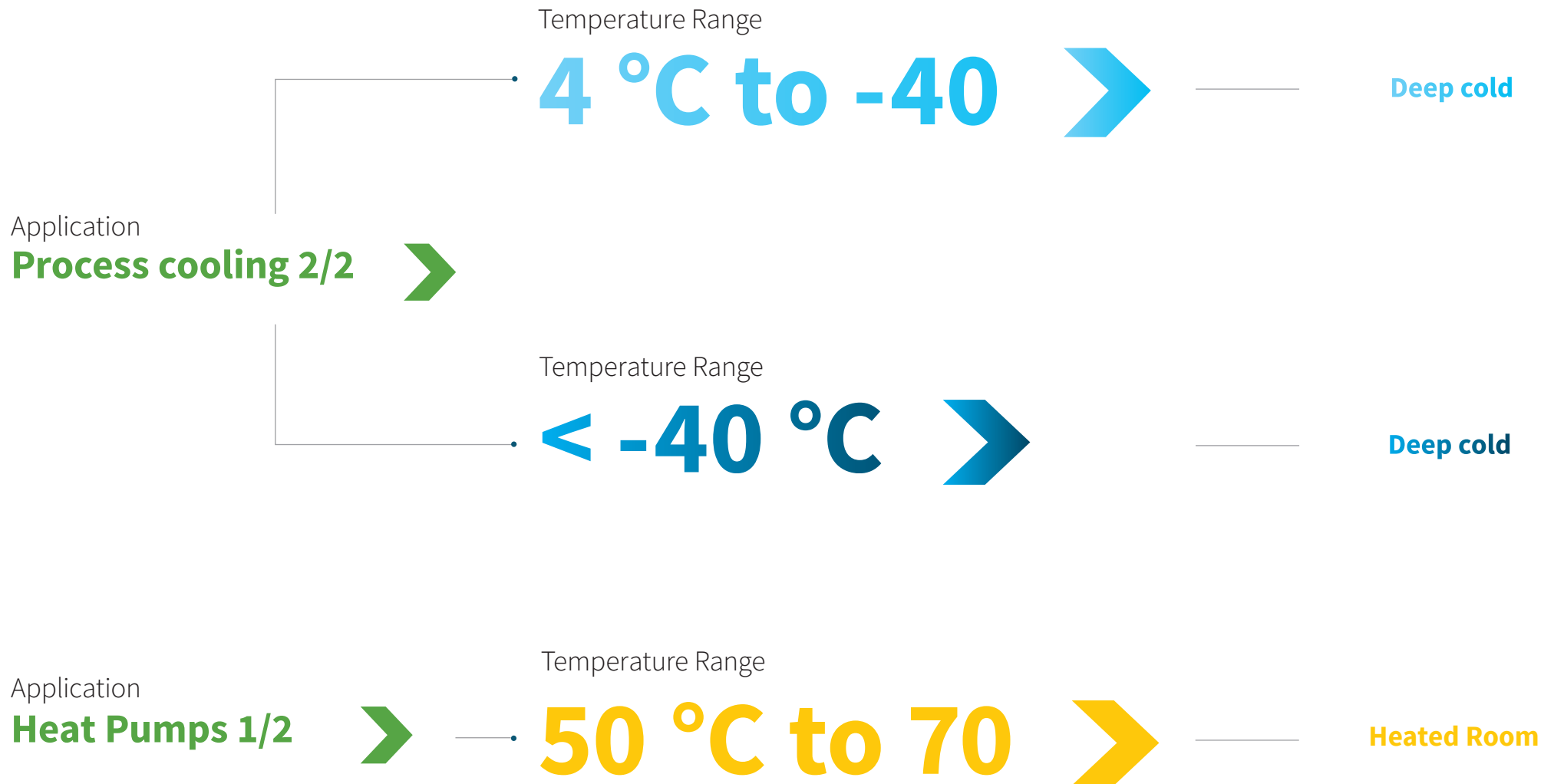
Case Study:
ABN Amro Data Centre

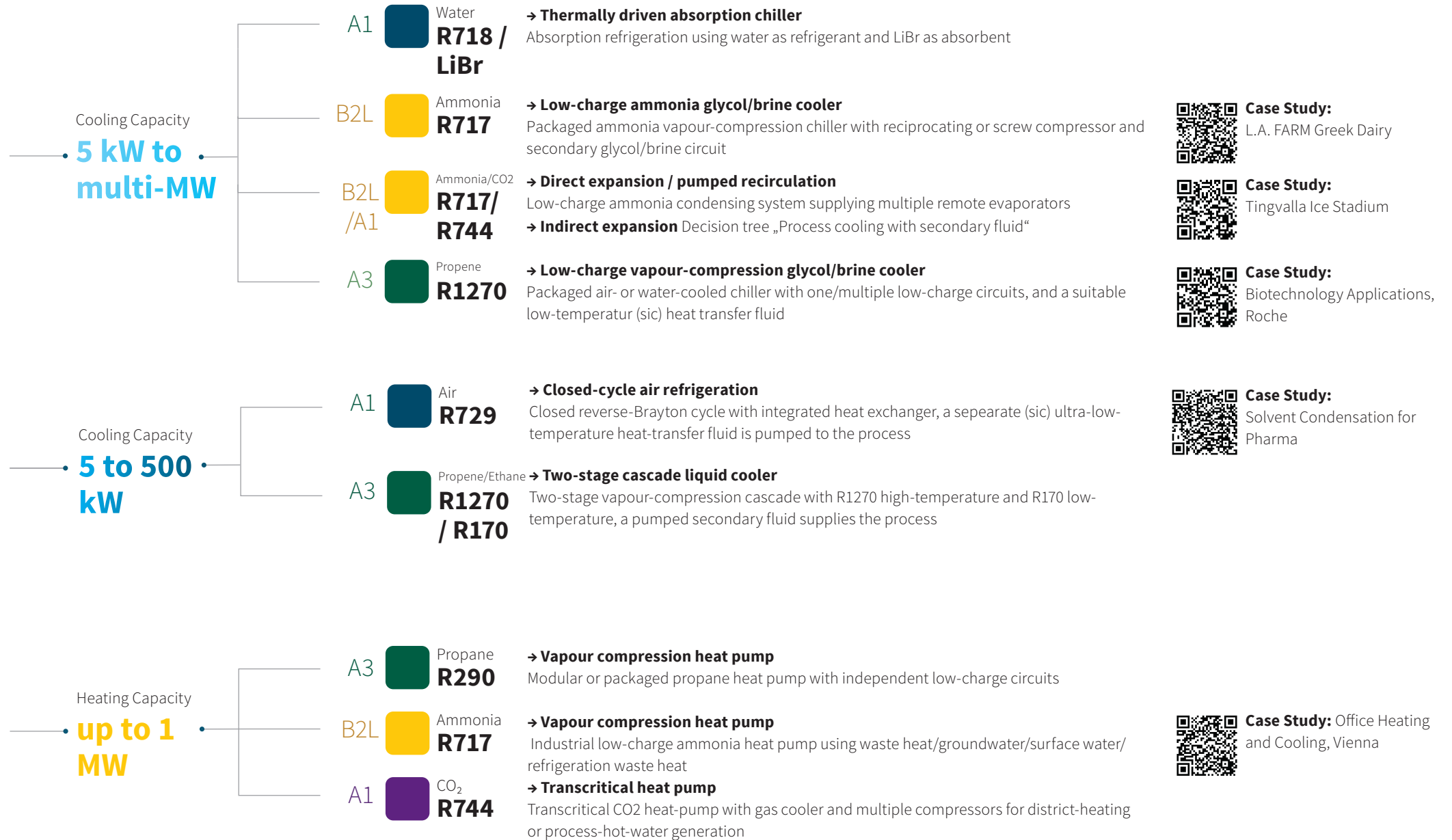


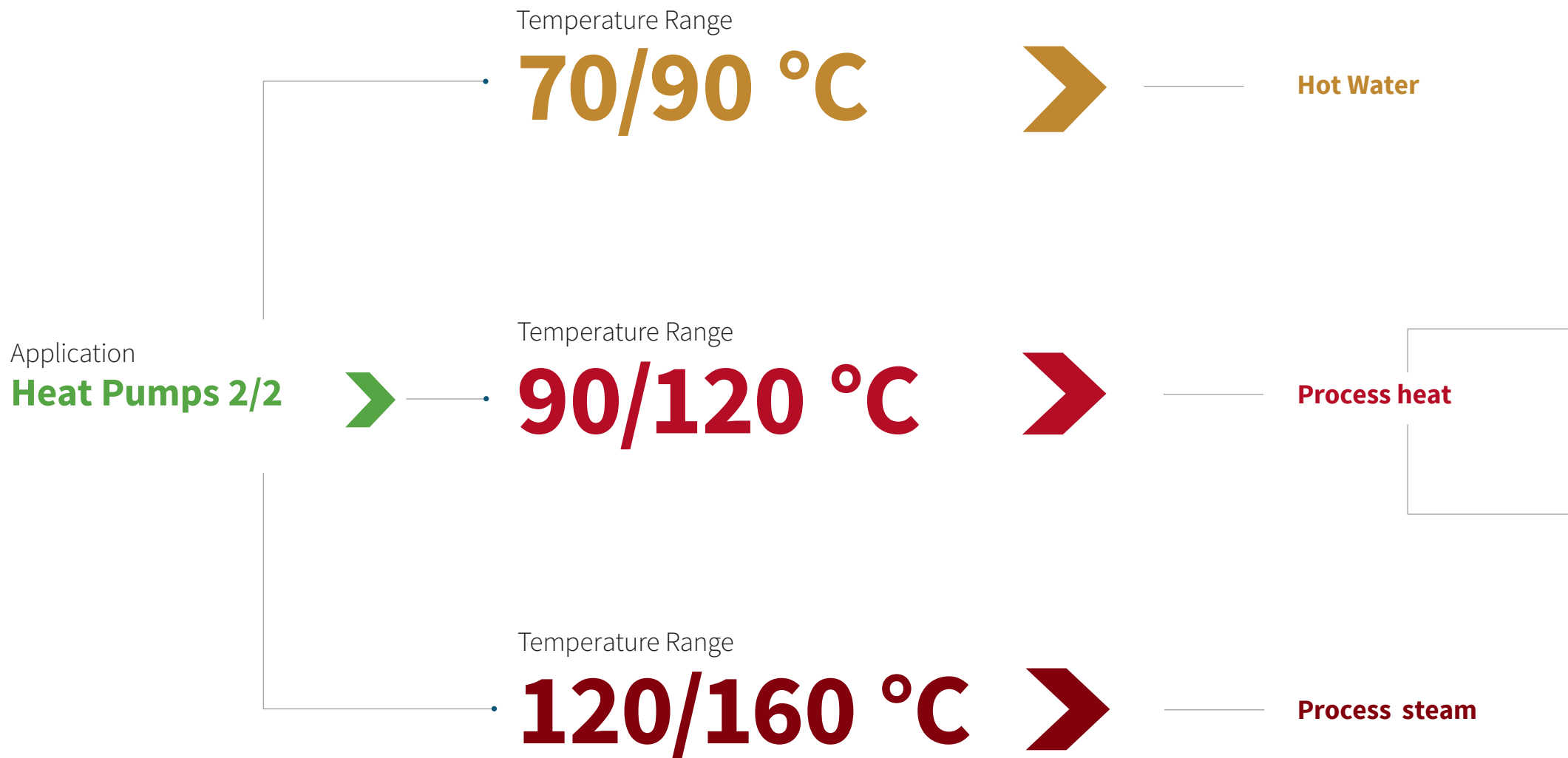
Case Study:
Penta Infra HAM01

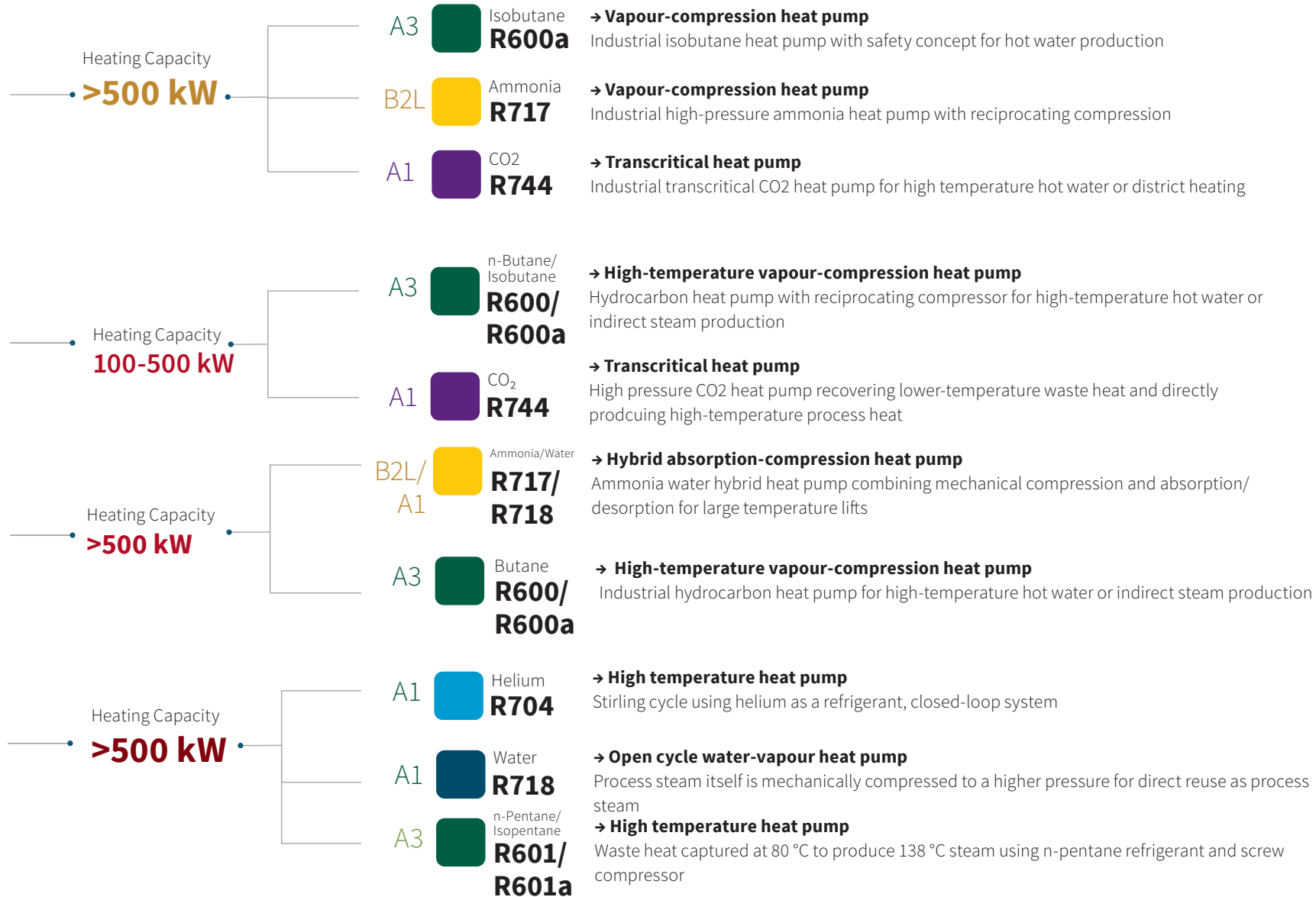


Case Study:
Schwarz IT Data Center









Case Study:
London District Heating

Refrigerants by Industry

Natural refrigerants are applied across a wide range of sectors, each with its own technical requirements and priorities. The table below provides an overview of the most relevant natural refrigerants used per sector, along with key topics specific to their application.

Sector	Natural Refrigerants	Key Topics
Logistics	R717, R717/R744 cascade, R729	Large-scale cold storage, energy efficiency benchmarks
Food & Beverage Manufacturing	R717, R744	Breweries, dairies, food and meat processing — hygiene-compatible system designs
Other Manufacturing	R290, R729, R717	Injection molding, cryogenic hardening of tools, carbon dioxide recovery
District Heating/ Cooling	R717	Large heat pump integration into district energy networks
Data Centres	R290, R717, R718	Free cooling and heat recovery integration, Power Usage Effectiveness, reliability
Leisure & Sports	R717, R744	Ice rinks with indirect brine loops, public area safety
Commercial Refrigeration	R744, R290, NH ₃ /CO ₂	Transcritical CO ₂ in supermarkets, energy savings
Pharma-ceuticals	R717, R729	Precise temperature control, GMP compliance, reliability
ACHP	R290, R744	Split AC systems, residential and industrial heat pumps

Regulatory Framework

The main regulations, standards and international frameworks to consider when deciding on the refrigerant for a RACHP system include:

Kigali Amendment to Montreal Protocol

The Kigali Amendment (adopted in 2016; in force since 1 January 2019) establishes the global phase-down of HFC production and consumption through differentiated country schedules. Parties are divided into three groups with differentiated obligations: (1) Non-Article 5 (developed countries), (2) Article 5 Group 1 (most developing countries), and (3) Article 5 Group 2 (10 high-ambient-temperature countries: Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, UAE). Overall, the Amendment is designed to reduce global HFC use by more than 80% over ~30 years and is estimated to avoid around 0.3–0.5°C of global warming.

Year
2024
2028
2036
2045
2047

Key Requirements
First reduction steps start for Article 5 Group 1 countries
Reduction steps start for Article 5 Group 2 countries
Developed countries reach an 85% reduction level (15% of baseline remaining)
Article 5 Group 1 countries reach an 80% reduction level
Article 5 Group 2 countries reach an 85% reduction level

EU F-Gas Regulation 2024/573

The F-Gas Regulation and the directives and standards below apply in the EU. Comparable national rules exist in other markets, and many follow the EU model.

The revised EU F-Gas Regulation (entered into force March 2024) establishes strict GWP limits and phase-down schedules as listed in the following:

■ (EU) Nr 517/2014

■ F-Gas Regulation (EU) 2024/573

a) New Baseline quantity: 176.700.479 to (=96,5 %)

b) 2027: Prohibition of new Chiller >12 kW with F-Gases GWP ≥ 750 (red, „F-Gases GWP ≥ 750 ” unterstrichen)

c) 2030: Prohibition of new Stationary refrigeration equipment with F-Gases GWP ≥ 150

PO) Phase-Out of HFC 2050

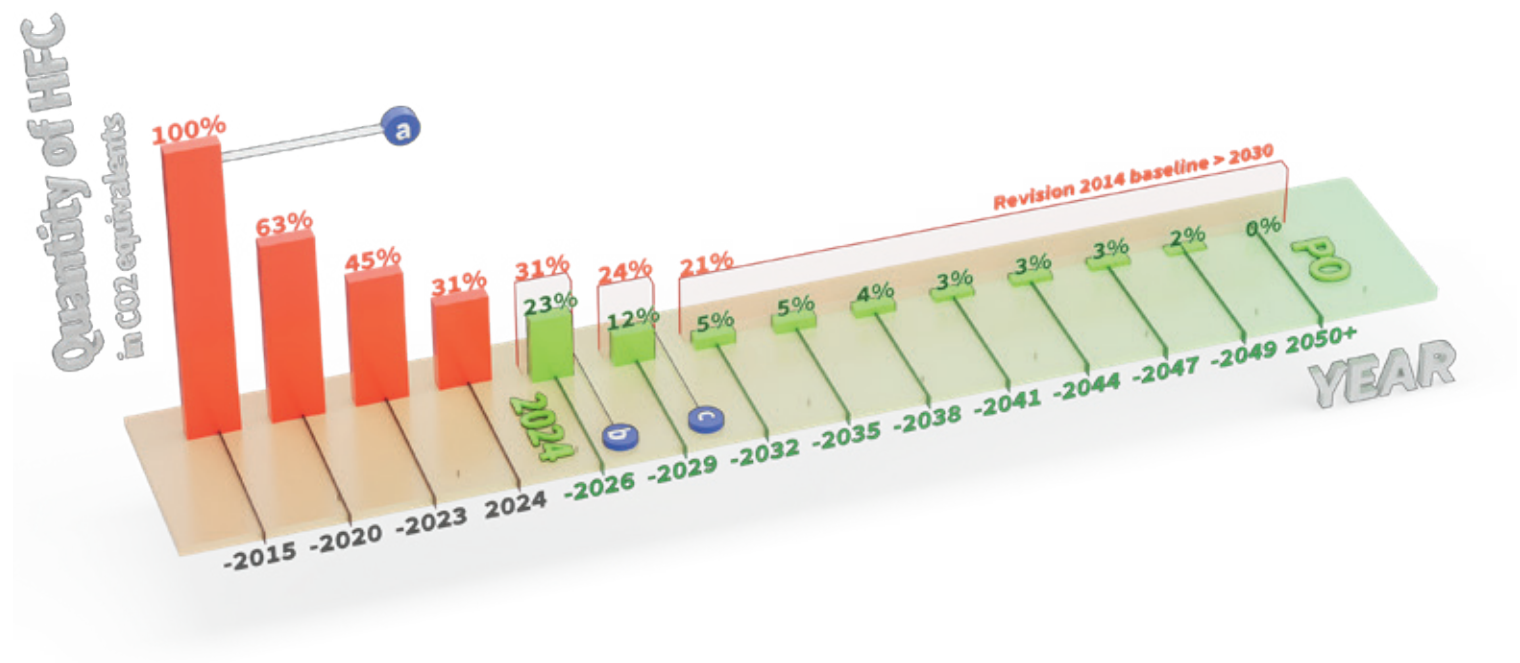


Figure 6: Revision 2024 of the (EU) F-Gas Regulation and Phase-Out of HFC. Source: Regulation - EU - 2024/573 - EN - EUR-Lex

European Directives on Health & Safety

Directive	Scope
Directive 1999/92/EC (ATEX Workplace Directive)	Requirements to protect workers where explosive atmospheres may occur
Directive 2014/34/EU (ATEX Product Directive)	Rules for placing on the market equipment and protective systems intended for use in potentially explosive atmospheres
Directive 2014/68/EU (Pressure Equipment Directive, PED)	Design, manufacture, and conformity assessment of pressure equipment and assemblies above 0.5 bar before placed on the EU market
Directive 89/391/EEC (OSH Framework Directive)	General prevention framework for worker safety and health across all sectors, including employer duties for risk assessment, prevention, training, and worker consultation

Key Safety Standards

Standard	Scope
EN 378	European standard for refrigerating systems – safety and environmental requirements
ISO 817	Refrigerant designation and safety classification
IEC 60335-2-24	Domestic refrigerating appliances
IEC 60335-2-40	Air conditioners and heat pumps
IEC 60335-2-89	Commercial refrigerating appliances

Note: EN 378 is currently under revision with expected improvements for natural refrigerant requirements.

PFAS

In recent years global concerns are rising over per- and polyfluoroalkyl substances (PFAS), including trifluoroacetic acid (TFA), a persistent environmental degradation product of modern hydrofluoroolefin (HFO) and HFC refrigerants. While designed to reduce global warming potential (GWP), HFOs degrade in the atmosphere to form TFA – a short-chain PFAS. TFA accumulates in water and soil and increasingly high concentrations have been found in drinking water, beverages, animals and food crops resulting in serious concerns on impact to human and animal health.

TFA's resistance to degradation and lack of large-scale remediation methods make it a mounting ecological and regulatory challenge. At EU-level a regulatory discussion on PFAS restriction under REACH, the European Union's chemicals regulation is currently underway.

Natural refrigerants are PFAS-free and provide a future-proof solution for sustainable cooling and heating.

Recommendations & Conclusion

Accelerating the uptake of natural refrigerants requires coordinated action across the supply chain. The figure below sets out concrete recommendations for system designers, end-users and operators, and policy makers across RACHP applications.

Across all refrigeration, air conditioning, and heat pump system (RACHP) application categories, commercially proven natural refrigerant options exist today. Natural refrigerants represent the most sustainable and efficient alternative to synthetic refrigerants. The regulatory direction is clear - EU F-Gas phase-out and the Kigali Amendment phase-down schedule eliminate the long-term viability of high-GWP refrigerants worldwide. As natural refrigerants align with global efforts to reduce environmental impact and comply with regulations and standards their use is expected to grow as industries seek to adopt more eco-friendly practices. The question for system designers, operators, and policy makers is no longer whether to transition, but how to do so efficiently.

System Designers

- 01.** Design for natural refrigerants from the start – retrofit is more costly than new design
- 02.** Consider indirect systems – secondary loops reduce refrigerant charge and are well-suited to specific application requirements¹
- 03.** Size systems appropriately – avoid oversizing; optimize for efficiency
- 04.** Follow applicable standards – EN 378, and product-specific EN standards
- 05.** Integrate safety measures – gas detection, ventilation, and leak minimization

End Users/Operators

- 01.** Prioritize natural refrigerants for new installations – they are future-proof
- 02.** Request lifecycle cost analysis – natural refrigerants often have lower total cost of ownership
- 03.** Ensure proper training for maintenance personnel
- 04.** Establish regular inspection schedules – preventive maintenance reduces risks
- 05.** Plan for end-of-life – natural refrigerants have simpler disposal requirements

Policy Makers

- 01.** Support training programs for technicians handling natural refrigerants
- 02.** Review building codes to enable broader natural refrigerant use
- 03.** Provide incentives for conversion to natural refrigerant systems
- 04.** Update standards to reduce barriers for manufacturers
- 05.** Include RACHP sector in national climate plans (NDCs)

01. Secondary loops are particularly suitable for: applications with high safety demands where refrigerants must remain in the machinery room; installations where long distances are an issue (to manage pressure drop in pipes); multiple-temperature applications; and food applications with food-contact certification requirements.

Further References

Organization	Resources	Website
Fraunhofer Institute	Research on heat pump performance and field studies, design of refrigeration systems, low charge circuits	www.fraunhofer.de
GIZ Green Cooling Initiative	Country cooling data, technical publications, tools, training materials, country reports and inventories, policy documents, webinars	www.green-cooling-initiative.org
IIAR – The International Institute of All-Natural Refrigeration	Standards, Ammonia Refrigeration Global Standards and Regulations, The Natural Refrigeration Review journal, training materials, information papers, videos, tools	www.iiarresources.org
IEA – International Energy Agency	The Future of Cooling (2018), Cooling Emissions and Policy Toolkit (2020)	www.iea.org
IIR – Institut International du Froid	FRIDOC Database covering all refrigeration sectors compiling documents from scientific and technical works from across the globe	www.iifiir.org/en/fridoc
UNEP OzonAction	Training and capacity-building resources on natural refrigerants for Article 5 countries under the Montreal Protocol	www.unep.org/ozonaction
UNEP TEAP	Technology and Economic Assessment Panel reports - authoritative data on refrigerant transitions by sector	www.ozone.unep.org

Further Reading and References

eurammon Resources

Resource	Description
Factsheets	Technical overviews of R729, R717, R744, and Hydrocarbons - eurammon.com/resources
Information Papers	In-depth guidance on natural refrigerants and their applications - Information papers eurammon
Case Studies	Documented real-world applications across industries - Case studies eurammon
video: "Naturally Cool"	History and use of natural refrigerants -YouTube: naturally cool - History and Development of Natural Refrigerants
Historical use	In early refrigeration systems in the late 19th and early 20th centuries



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Disclaimer

This guide is intended as general technical orientation for professionals in the RACHP sector. It does not constitute engineering design advice and does not replace project-specific system design, risk assessment, or compliance with applicable standards and national regulations — including EN 378, the IEC 60335 series, the Pressure Equipment Directive 2014/68/EU, the ATEX Directives, and local building, fire and workplace safety codes.

The figures and decision trees in this guide are simplified representations intended to orient the reader. They do not cover every system variant, site constraint or national requirement. Safety classifications, charge limits and regulatory requirements are stated as at September 2026 and are subject to change; EN 378 is currently under revision. All values must be verified against the current editions of the relevant standards and against the specific installation.

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