R134A VERSUS AMMONIA ?

York / Johnson Controls
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Overview : R134a versus ammonia

- Short presentation of Johnson Controls
- Intro in ecodesign
- F-gas : York's point of view
- Characteristics of Ammonia
- Chillers using both refrigerants : ammonia and R134a
- Examples of installations
- Conclusion

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Un leader technologique et industriel mondial dans le domaine de l'automobile, des bâtiments et le stockage d'énergie.

Automotive Experience

Automotive Experience est un leader mondial de systèmes de sièges, panneaux de portes, consoles centrales et tableaux de bord.

Building Efficiency

Fabricant de solutions et components pour l'automatisation de bâtiments, sécurité, conditionnement d'air et refrigération commerciale et industrielle.

Power Solutions

Johnson Controls Power Solutions est le leader mondial de la fabrication de batteries de démarrage de pointe pour les véhicules « Stop et Start » et de batteries au lithium-ion dédiées aux véhicules hybrides et électriques.

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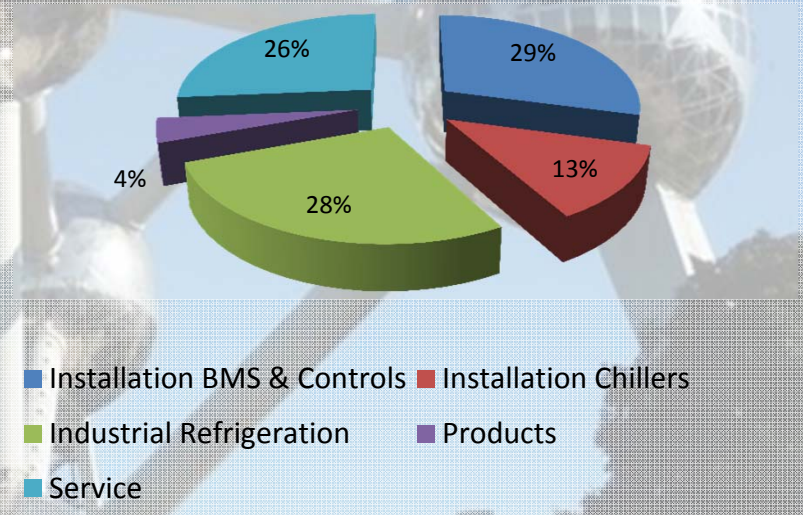
Building Efficiency Belux



$50
Million de chiffre d'affaires en 2015

141
employés

Building Efficiency Belux

Building Systems

- Régulation Digitale
- Gestion Technique Centralisé
- Securité

Building Service

- Régulation Digitale
- Gestion Technique Centralisé
- HVAC
- Securité
- O&M/M&E
- Service & Retrofit

Refrigeration Industrielle & YORK

- Réfrigeration Industrielle
- Contracting
- Equipment Sales
- Service & Parts
- Compressor Remanufacturing
- Small tonnage chillers
- Large tonnage chillers

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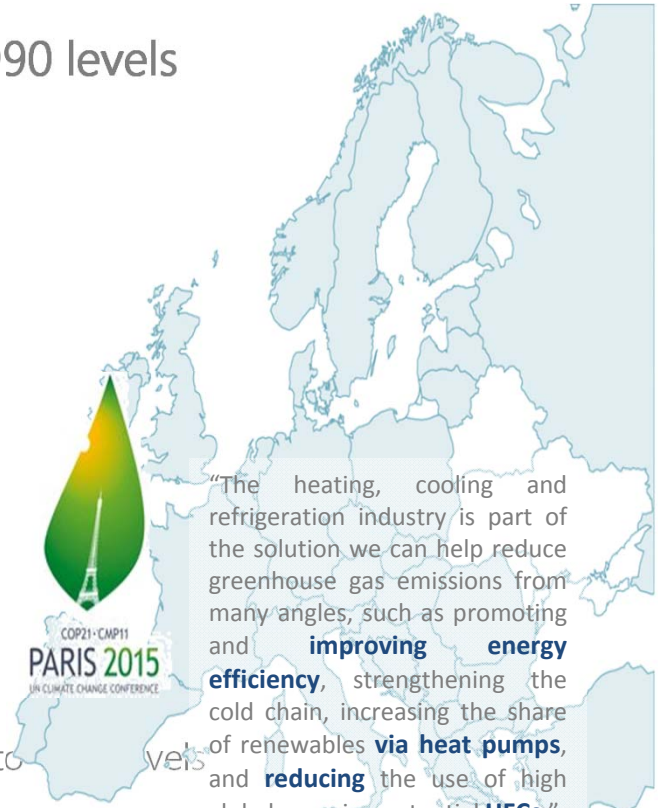
EU Energy and Climate Policy context

- Europe 2020 Strategy (20/20/20), compared to 1990 levels
  - -20% primary energy consumption
  - -20% Green-house effect gases emissions
  - +20% use of renewable energies
- Europe 2030 Strategy, compared to 1990 levels
  - -27% primary energy consumption
  - -40% Green-house effect gases emissions
  - +27% use of renewable energies
- Europe 2050 vision
  - Towards a low carbon economy
  - -80-95% greenhouse effect gases emissions compared to 1990 levels



"The heating, cooling and refrigeration industry is part of the solution we can help reduce greenhouse gas emissions from many angles, such as promoting and **improving energy efficiency**, strengthening the cold chain, increasing the share of renewables **via heat pumps**, and **reducing** the use of high global warming potential **HFCs**." EPEE Director General - Andrea Voigt

…Buildings account 40% of the Energy consumption in Europe, they are key to achieve the targets…

Source:
http://ec.europa.eu/energy/en/topics/energy-strategy, http://www.epeeglobal.org/news/news/details/article/epee-welcomes-paris-agreement-and-pledges-to-continue-activities-to-combat-climate-change/

There are key Directives that are already affecting market dynamics…

Energy and Climate related directives in Europe and their impact on us:

EED	▪ Energy Efficiency Directive (2012/27/EU) ▪ Driving efficiency, leading to reduce waist energy & retrofit buildings ▪ Major impulse due to 3% of governments buildings be renovated each year. ▪ **Requires market / government needs compliant controls (i.e. B-AWS).**
EPBD	▪ Energy Performance of Buildings Directive (2010/31/EU) ▪ nZEB* mandatory by Jan. 2019 (public), Jan. 2021 (others) ▪ **Driving Efficiency in Buildings, leading to for example smaller more efficient chillers..** ▪ **… as well as increasing number of controls (OEM) and with higher complexity.**
Ecodesign	▪ Eco-Design Directive (2009/125/EC) ▪ Ban for products below minimum seasonal energy efficiency levels (non CE mark) ▪ **Driving efficiency requirements focus on part load efficiency, requiring better controls**
RES	▪ Renewable Energy Sources Directive (2009/28/EC) ▪ Recognize heat pumps as renewable source, if technology meets minimum efficiency requirements. ▪ **Driving growth for Heat Pumps**
FGAS	▪ F-Gas regulation (517/2014) ▪ Phase down for HFCs used in HVAC (Chillers). Baseline 2015, -79% by 2030 ▪ **Driving low GWP based product offering**

Lower capacity chillers, more controls, sensors, valves, actuators & metering to provide higher part load efficiencies, growth in heat pumps and low GWP refrigerants

Source: http://eur-lex.europa.eu/homepage.html

Notes:
* nZEB (nearly Zero Energy Buildings)

What is Eco-Design?

- A tool of the EU to improve Energy Efficiency of « ERP's » (Energy Related products),
- Implementation of **EU directive 2009/125/EC** (revision ongoing).
- Complementary with **Energy Labelling Directive 2010/30/EU**.
- Both are the pillars of the EU policy to support the **« 20-20-20 » targets.**
- The « Framework » directive sets general rules. These rules are next detailed in to binding « IM's » (Implementing Measures) for various categories of products (e.g various appliances, lighting, air conditioners etc).
- Implementing measures are typically about mandatory energy labeling (mostly for B to C products), and (or) « MEPS » (Minimum Energy Performance Standards), leading to progressive ban of the less efficient products.

Eco-Design is an essential requirement of CE marking, together with PED, EMC and Machinery Directive

Projects (Lots) within the Ecodesing Framework Directive 2009/125 EC

Commissions Energy **(ENER)** and Enterprise **(ENTR)**

ENER Lot.			ENTR Lot
1. Boilers	10. Air Cond < 12 kW	20. Local Room Heating	1. Refrigeration
2. Water Heaters	11. Motor, fans... - Under revision -	21. Central heating, cooling products	2. Transformers
3. PC	12. Com. Refrigerators	….	3. Multime
	13. Domestic Refrig.	….	4. Industr. f
	14. Dish washers		5. Machine
	15. Fossil fuel burne	30. Motors / Drives	6. A/C and V
7. Battery charger	16. Laundry Dr	31. Com	
8. Office lights			
9. Street Lights			

Ecodesing regulation 813/2013 and labelling regulation 811/2013: Space and combination heaters

No Ecodesign/labelling regulation yet but in final stage

- HT Process Chillers
- Comfort A/C Chillers
- Air Heating Heat Pumps (Air to Air – Rooftops / VRF)
- Fan coil units

Professional refrigerating and freezing equipment: Ecodesign regulation 2015/1095 and labelling regulation 2015/1094

- MT & LT Process Chillers
- Condensing Units

t main work items HVAC&R (under revision)

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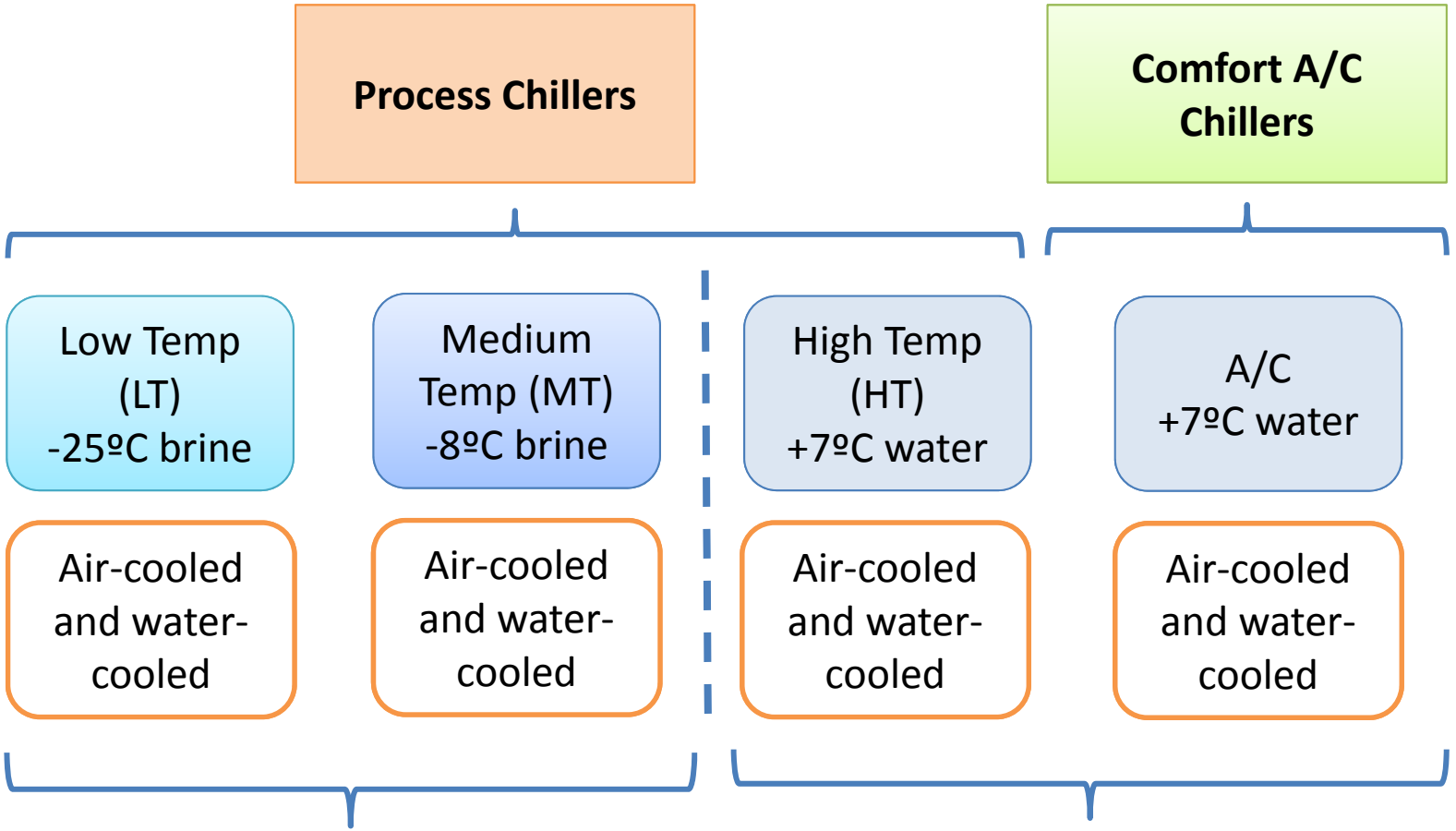
Johnson Controls

ENTR Lot 1 / ENER Lot 21

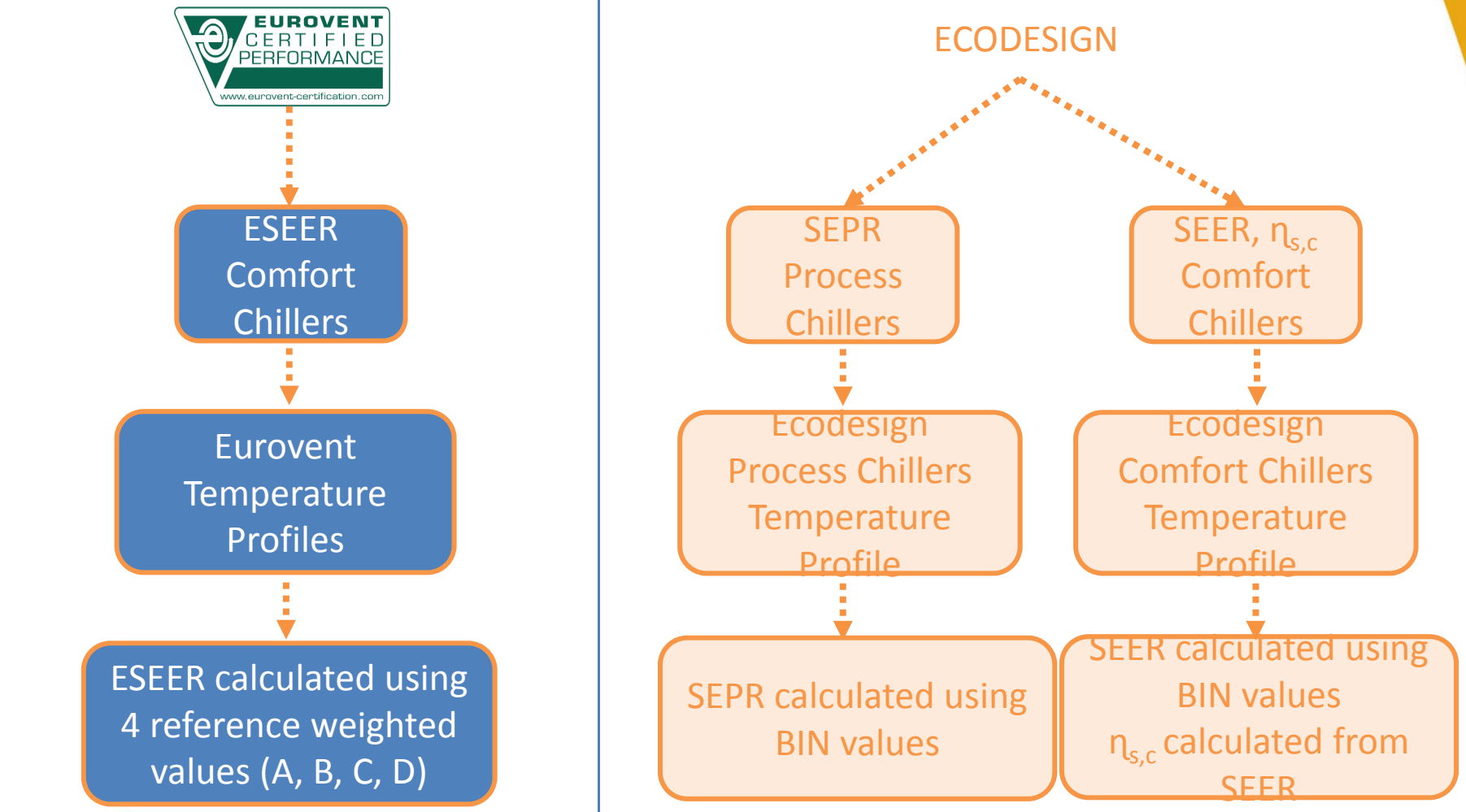
Application Ranges for Chillers



This is already a EU regulation (2015/1095) that applies from July'15

Draft at final approval stage

Main differences between Eurovent and Ecodesign MEPS



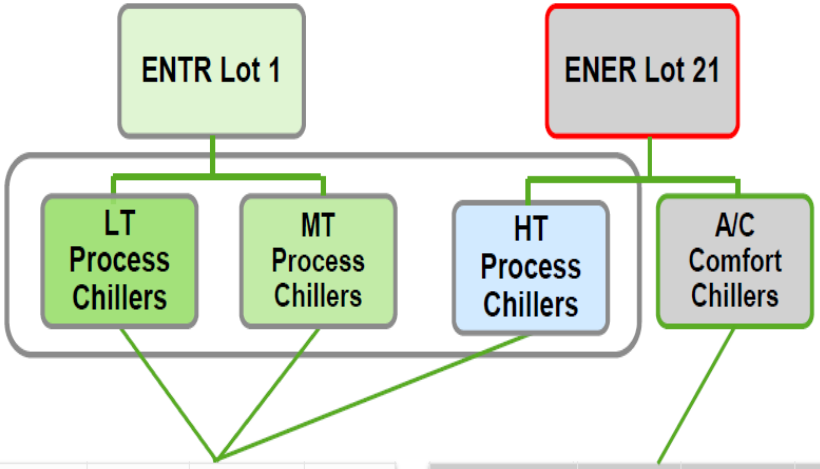
Load and Temperature Profiles

ESEER Comfort Chillers

	Air-cooled t_{amb} (ºC)	Water-cooled t_{water} (ºC)	Load (%)	Weighted coefficiency (%)
A	35	30	100	3
B	30	26	75	33
C	25	22	50	41
D	20	18	25	23

ESEER = (EER@100% load × 0.03) + (EER@75% load × 0.33) + (EER@50% load × 0.41) + (EER@25% load × 0.23)

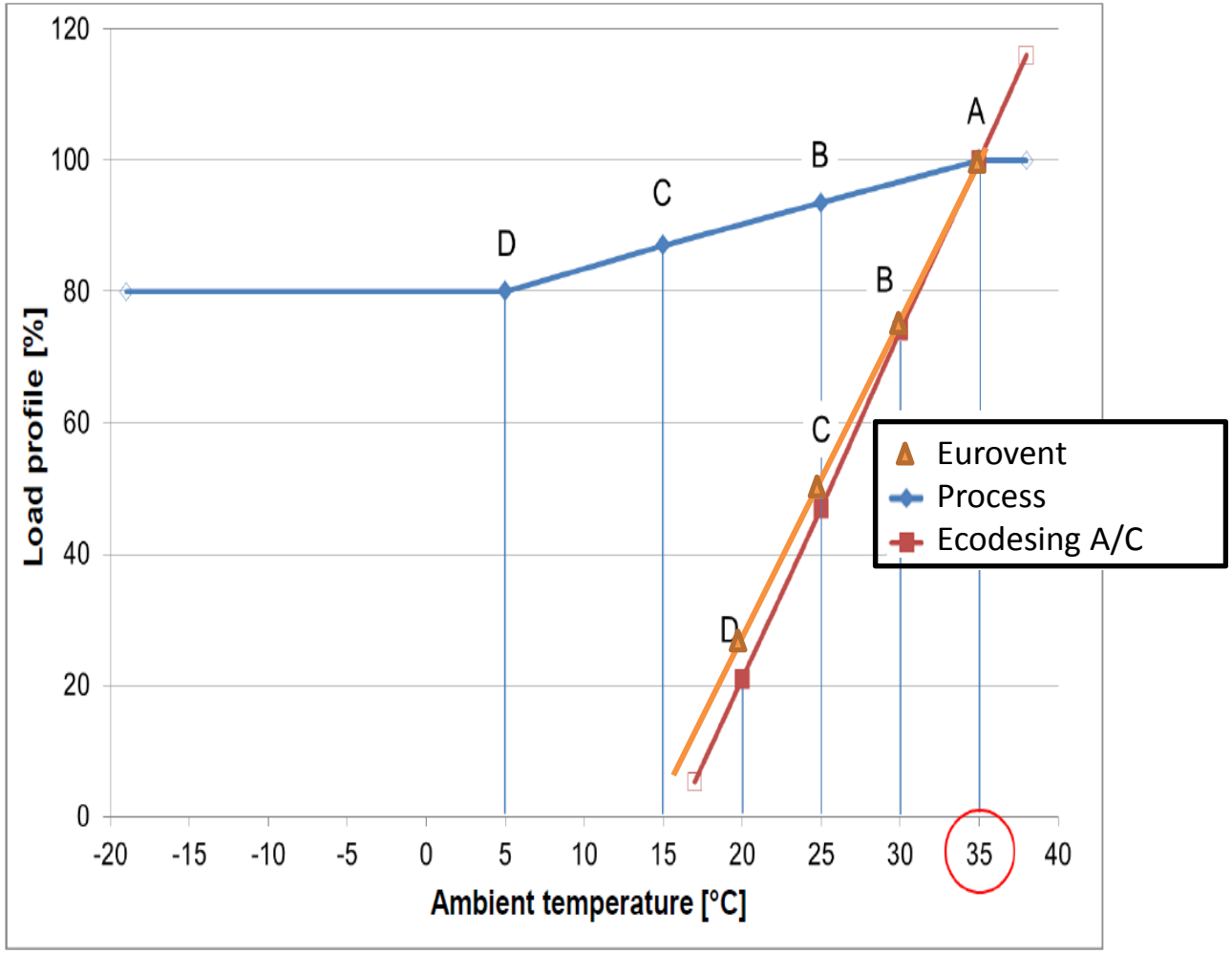
ECODESIGN



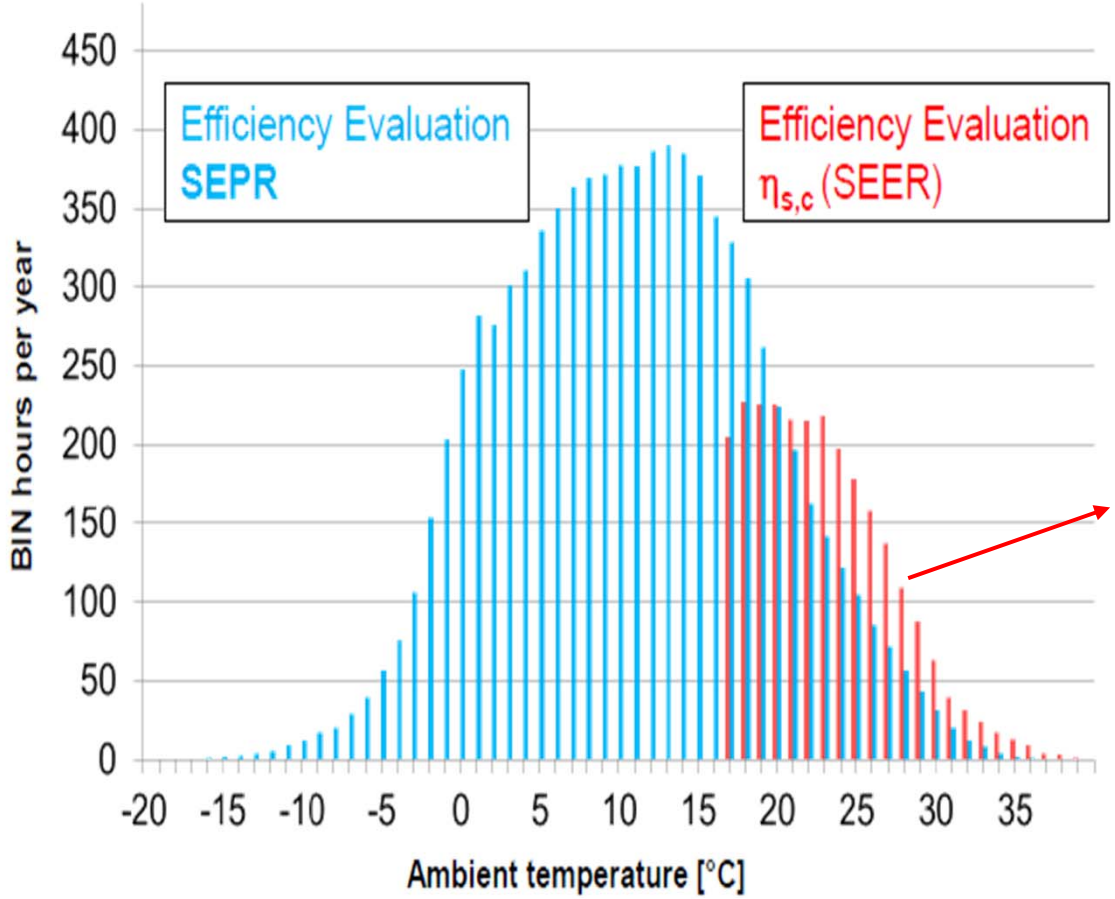
Reference Condition	air-cooled t_{amb} [°C]	water-cooled t_{water} [°C]	load [%]
A	35	30	100
B	25	23	93
C	15	16	87
D	5	9	80

Reference Condition	air-cooled t_{amb} [°C]	water-cooled $t_{water.}$ [°C]	load [%]
A	35	30	100
B	30	26	74
C	25	22	47
D	20	18	21

Liquid Chillers – Load Profile vs. Ambient Temperature



Temperature Profile ENER Lot 21* (EN 14825) for A/C Chillers – vs. Temperature Profile Strasbourg

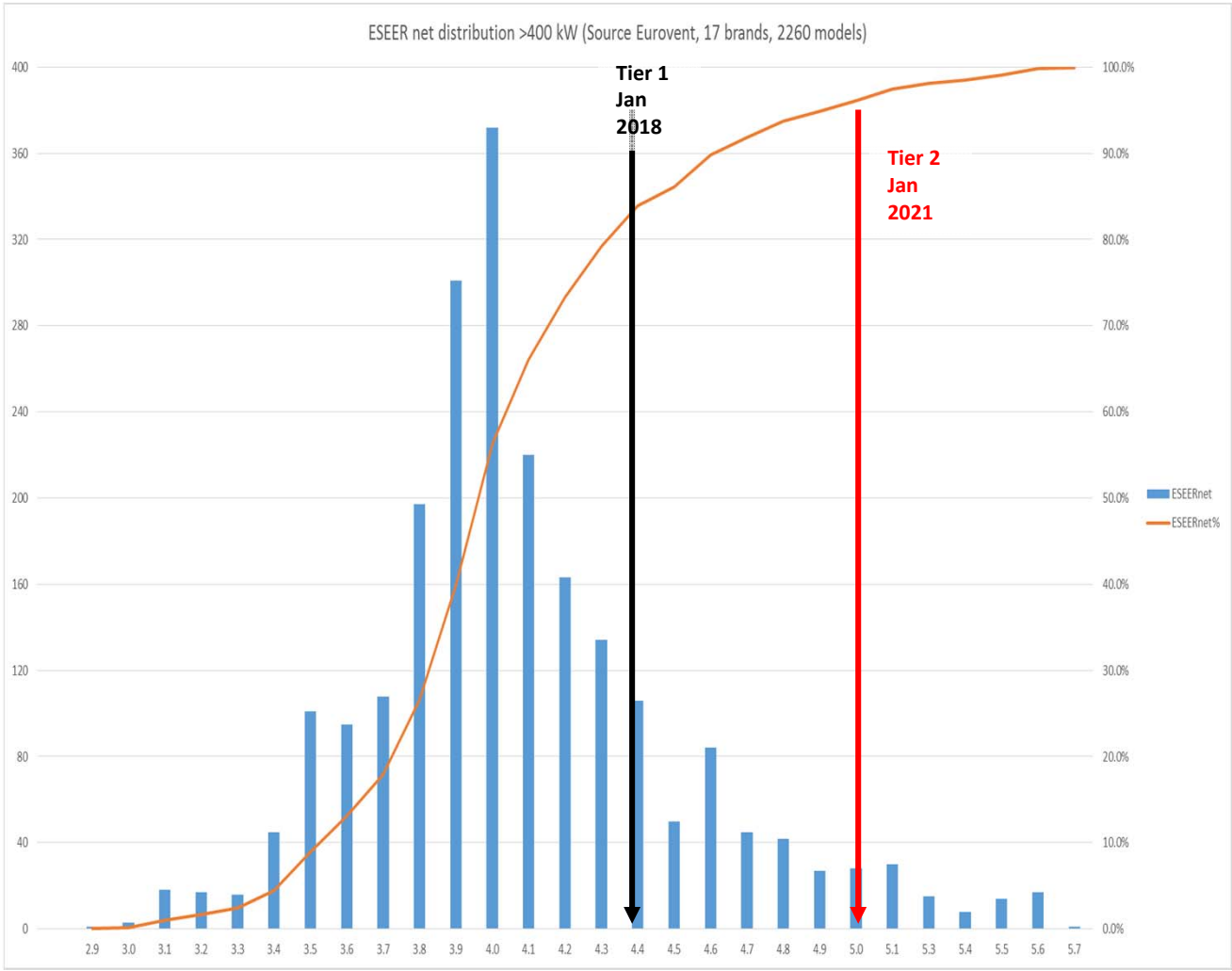


For Ecodesign Comfort Chillers the ambient temperatures considered are above 15ºC. Total hours = 2,602

* based on EN 14825

ESEER net

AC >400 kW, all units on eurovent and Ecodesign Tier 1/2



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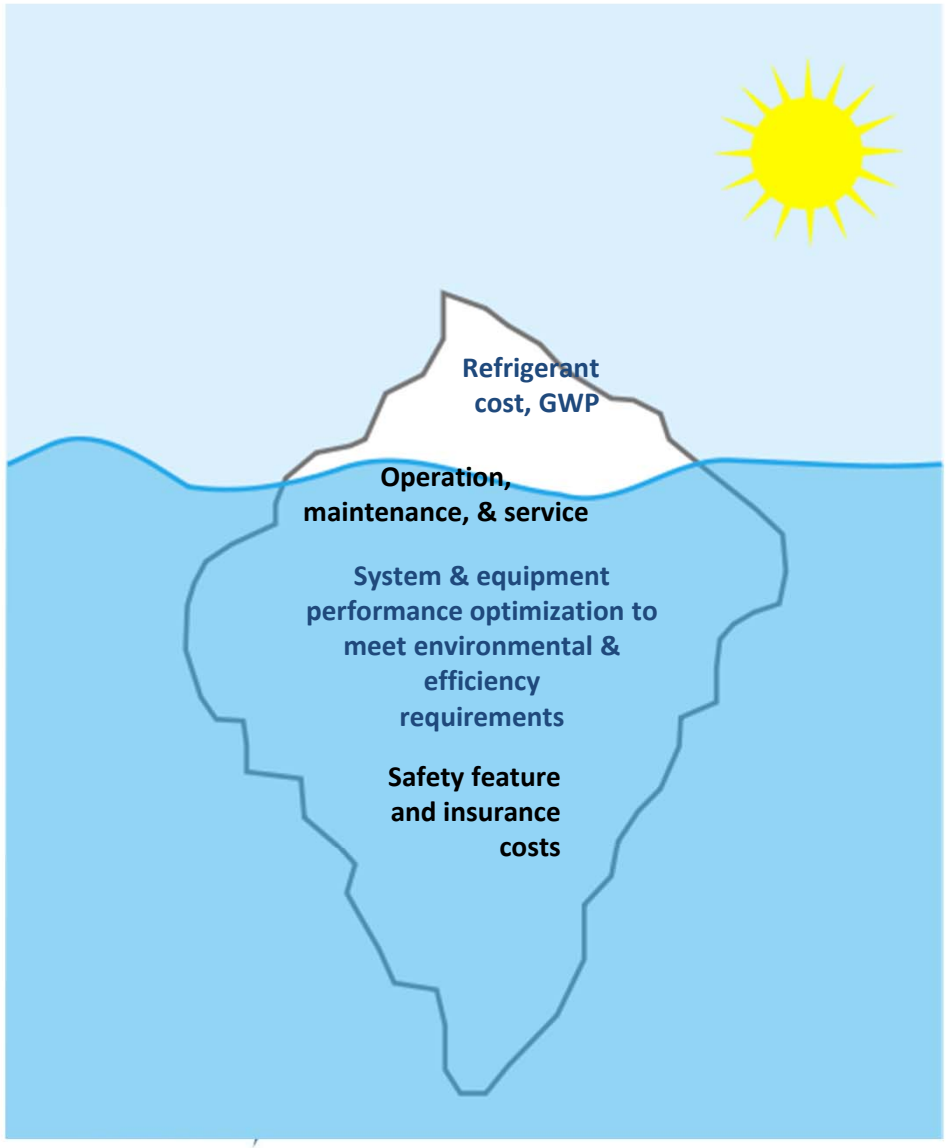
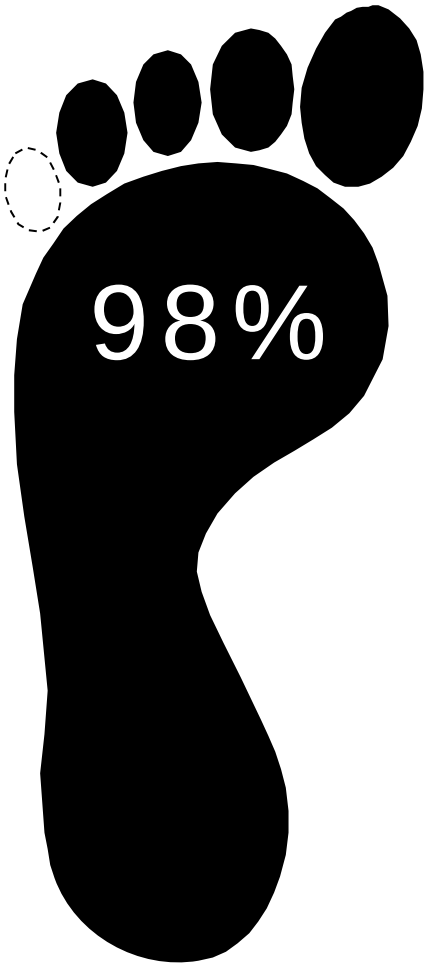
Refrigerant Selection is Complex and Cannot be Based on Just 1 or 2 Factors



- Refrigerant GWP & cost is only part of a complex decision
- Refrigerant selection based on a single criteria can have adverse life-cycle cost, performance and environmental impacts

A Typical Chiller's Carbon Footprint



98% of the total global warming impact is indirect emissions of CO_2 due to electric energy usage, production and disposal of the equipment

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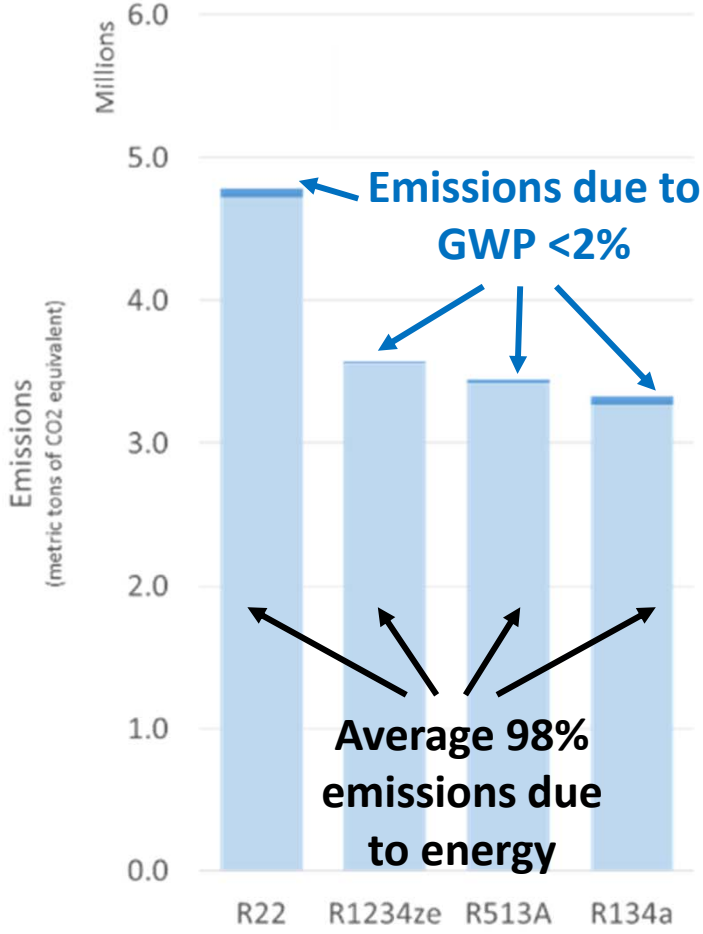
Efficiency has a much greater impact on emissions than refrigerant GWP

- Total equivalent warming impact (TEWI) provides a net impact of performance including refrigerant emissions and energy consumption
- Energy efficiency is the most effective means of reducing greenhouse gas emissions from chiller products
- R-134a provides best life cycle climate performance with the lowest greenhouse gas emissions of all four refrigerants due to its high efficiency.



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Assumptions: Air-cooled screw chiller, 5.15 COP, 0.4 kg CO_2/kWh, 15 year chiller life, 2% leak rate, 90% reclaim

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Eigenschappen van Ammoniak

A. Milieu-impact

		ODP	GWP
R12	CF2CL2	1	10600
R22	CHCLF2	0,055	1900
R134a	CH2FCF3	0	1360
R407a	Blend	0	1920
R717	NH^3	0	0
R744	CO^2	0	1

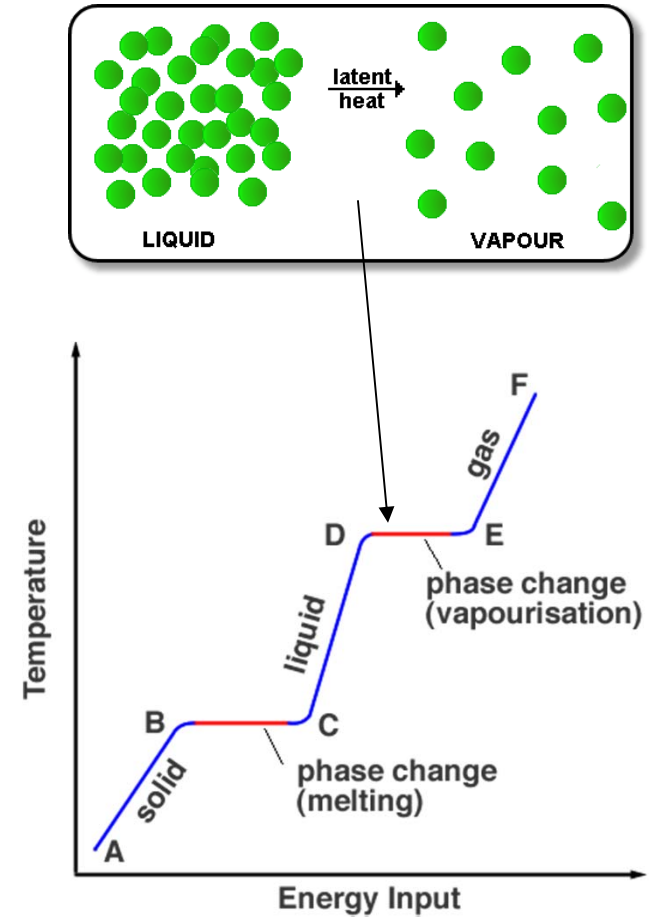
NH3 = milieuvriendelijkste!!

(*) ODP = Ozon Depletion Potential (Ref = R11)
(**) GWP = Global Warming Potential (kg CO2/100J)

Eigenschappen van Ammoniak

C. Latente warmte

		(0°C) kJ/kg
R12	CF2CL2	151
R22	CHCLF2	205
R134a	CH2FCF3	197
R407a	Blend	222
R717	NH^3	1260
R744	CO^2	231

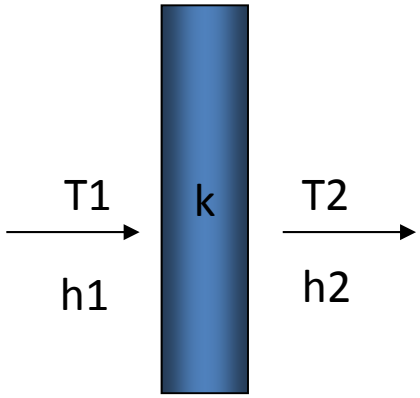


NH3 = grootste latente warmte

Minder volume om evenveel energie
te transporteren...

Eigenschappen van Ammoniak

D. Warmtegeleidbaarheid

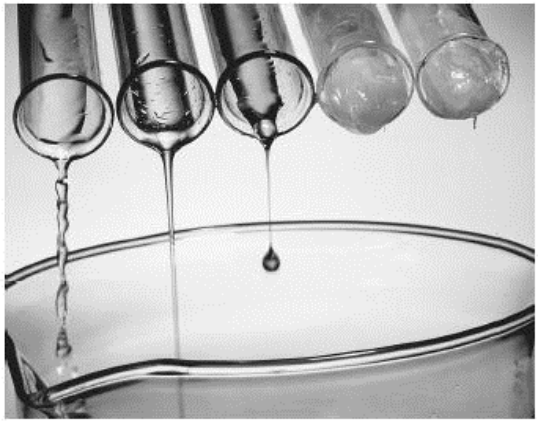


		(x 10-3) W/m.K
R12	CF2CL2	8,855
R22	CHCLF2	9,999
R134a	CH2FCF3	12,28
R407a	Blend	11,1
R717	NH^3	23,8
R744	CO^2	19,39

NH3 = grootste warmtegeleidbaarheid!!

Eigenschappen van Ammoniak

E. Lage viscositeit



		Dynamische Viscositeit (10^ -3kg/m*s)
R12	CF2CL2	0,01156
R22	CHCLF2	0,01196
R134a	CH2FCF3	0,01284
R407a	Blend	0,01127
R717	NH^3	0,01035
R744	CO^2	0,01431

NH3 = laagste viscositeit

Hetgeen resulteert in lagere drukverliezen

Eigenschappen van Ammoniak

F. Grootste specifieke volume / laagste specifiek gewicht

		Specifiek Volume (dm³/kg) 0°C Vloeistof	Specifiek Volume (dm³/kg) 0°C damp
R12	CF2CL2	0,716	55,436
R22	CHCLF2	0,778	47,15
R134a	CH2FCF3	0,773	69,005
R404a	Blend	0,871	34,174
R717	NH^3	1,566	289,128
R744	CO^2	1,076	10,2885

		Densiteit (kg/dm³) 0°C Vloeistof	Densiteit (kg/dm³) 0°C damp
R12	CF2CL2	1,3966	0,0180
R22	CHCLF2	1,2853	0,0212
R134a	CH2FCF3	1,2937	0,0145
R404a	Blend	1,1481	0,0293
R717	NH^3	0,6386	0,0035
R744	CO^2	0,929	0,0972

Hetgeen resulteert in minder volumetrisch debiet voor dezelfde koelcapaciteit dus kleinere compressoren/leidingen .

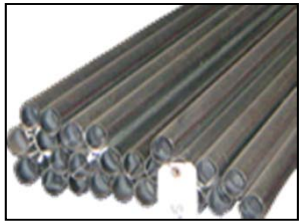
Eigenschappen van Ammoniak

C. Corrosief:

Freons

€

NH3

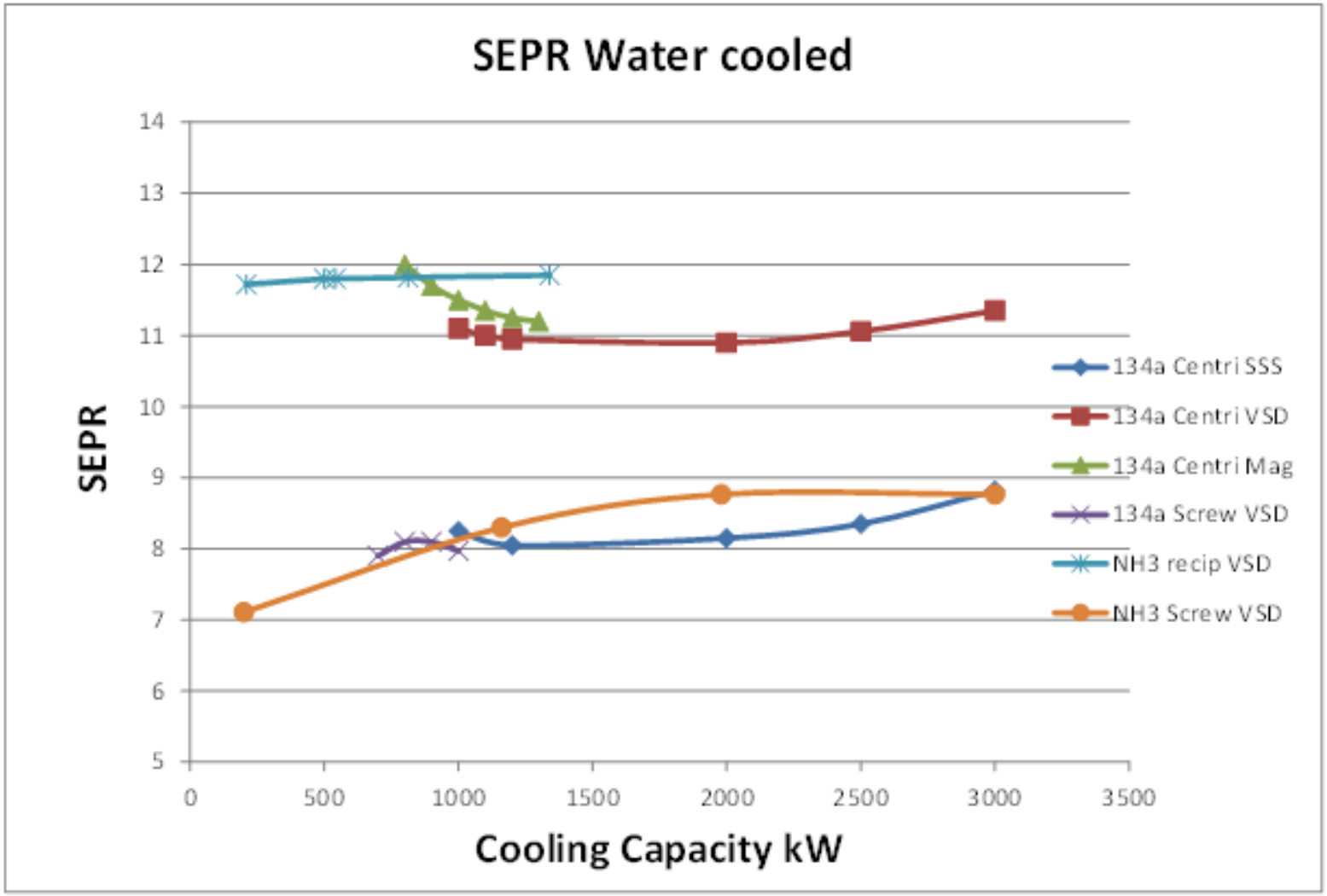


€€

NH3 = Corrosief en tast Cu aan!

Staal/RVS dient gebruikt te worden voor de installatie.
Dit impliceert duurdere chillers en installaties.

Vergelijking van watergekoelde chillers : ammonia versus R134a voor een proces chiller met 7 °C ijswater



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Eigenschappen van Ammoniak

G. Altijd beschikbaar & goedkoop

	€/kg	beschikbaar
R1234 yf	520	Ja maar
R22	-	-
R134a	23,89	Ja maar
R407a	38,84	Ja maar
R717/NH3	2,66	Altijd
R744/CO2	1,52	Altijd

NH3 = goedkoopste & altijd beschikbaar.

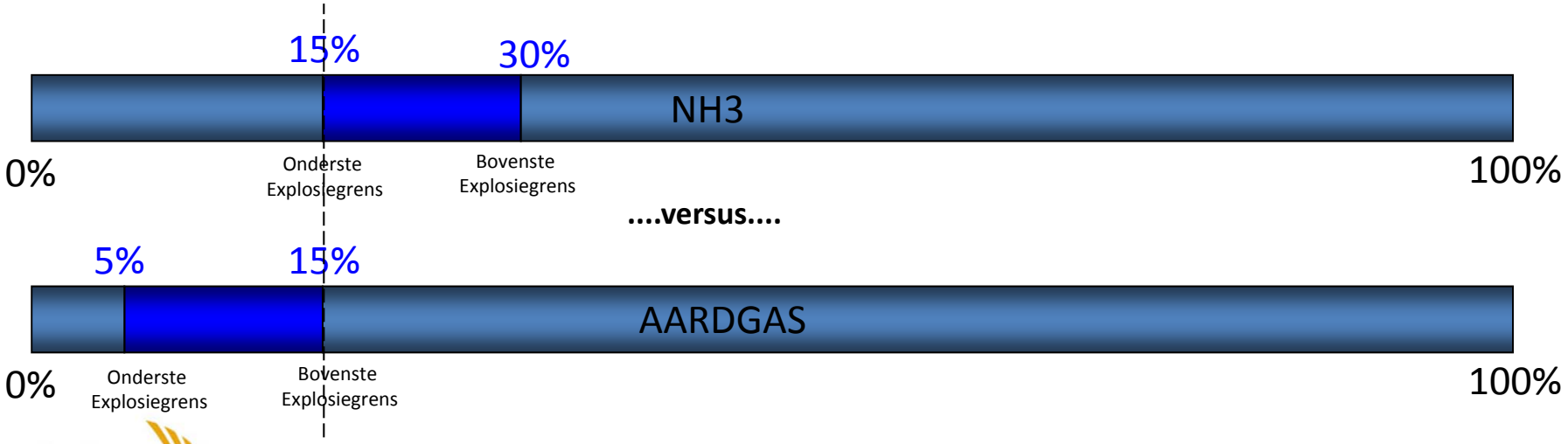
Eigenschappen van Ammoniak

A. Explosiegevaar:

Algemeen: NH3 heeft een lagere waarschijnlijkheid op ontbranding dan Aardgas.

	NH3	Aardgas
Ontstekingstemperatuur	630°C	650°C
Verhouding vlamsnelheid	1/15	15/15
Brisanz-factor (*)	1/7	7/7

(*) Brisanz = Energie dat vrijkomt gedurende de ontbranding



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Eigenschappen van Ammoniak

B. Giftigheid:

NH3

- Is lichter dan lucht.
- Ruikt men reeds bij 5 ppm.
- Dodelijk bij 1700 ppm / 30 min.
- Dodelijk bij 5000 ppm / 2 min.

- Valt bij open vuur uiteen in Stikstofoxyde en waterdamp. (geen gevaar)

Freons

- Is zwaarder dan lucht.
- Ruikt men niet.
- Dodelijk bij 10% / 2 uur
- Dodelijk bij 20% / 5 min.

- Freons vallen bij open vuur uiteen in Fosforgas (dodelijk!).

*Goede **lekdetectie** en **afzuiginstallatie** kunnen dit nadeel verhelpen.*

Voorzieningen in een gebouw met NH3

- NBN EN 378 – 3 te volgen (dit voor alle koelmiddelen)
  - Sectie 5.17 specifiek voor koelmiddelen A2, A3, B2 en B3
    - 5.17.1.2 : Emergency exhaust ventilation (outside the room or Made for Hazardous execution)
    - 5.17.2 special for ammonia : drainage closed, eye wash facilities (for installations above 1000 kg a shower to be forseen), no fire sprinklers in the technical room
  - Sectie 8 detectors : detection systems to be installed for refri with gwp > 0 if system is greater than 25 kg
    - 8.7 : ammonia detection needed for charge size more than 50 kg and having :
      - Prealarm above 500 ppm (ventilation activated)
      - Main alarm above 30000 ppm (refrieration system to be stopped)

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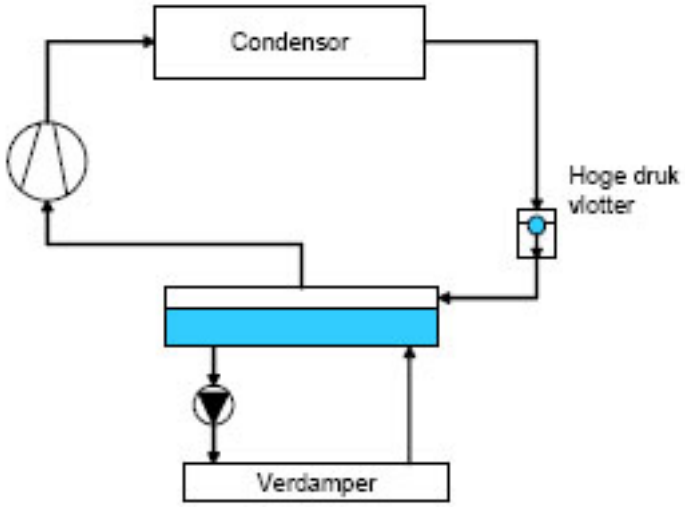
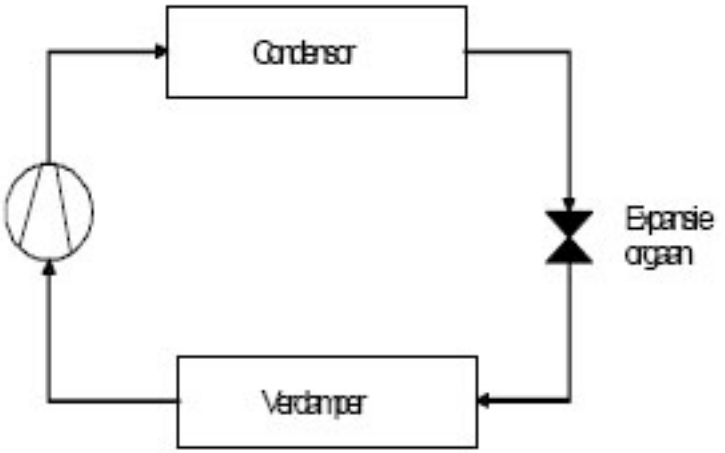
Ammoniak Installaties – Principe 1



Pompcirculatiesysteem

- Toepassingsgebied: Koel- en vrieshuizen, brouwerijen, levensmiddelenindustrie
- Traditionele & efficiente werkingsmethode
- Werkingsgebied: -40°C tot 20°C
- Tweetrapssystemen bij temperaturen die doorgaans lager liggend an -20°C.
- Relatief grote koudemiddelinhoud.

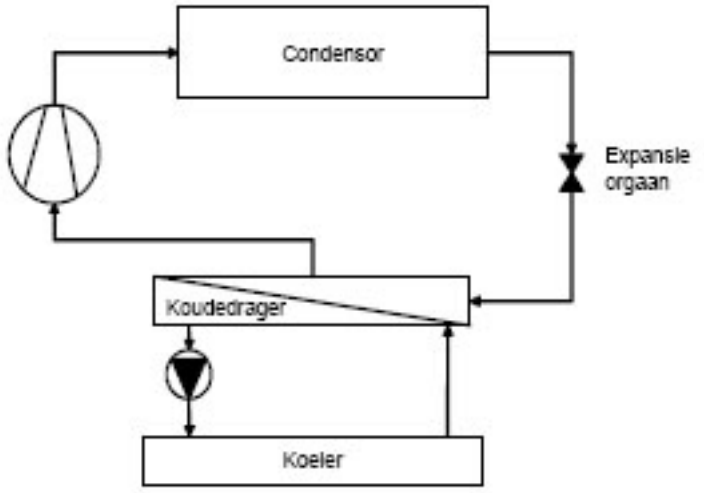
Ammoniak Installaties – Principe 2



DX systeem

- Toepassingsgebied: Airconditioning & proceskoeling.
- Chillers met geregeld expansieventiel
- Directe expansie van NH3
- Kleinere koudemiddelinhoud dan pompcirculatie-systemen.

Ammoniak Installaties – Principe 3



Indirecte DX-systeem

- Toepassingsgebied: Airconditioning & proceskoeling.
- Chillers met geregeld expansieventiel
- Directe expansie van NH3
- Kleinere koudemiddelinhoud dan pompcirculatie-systemen.
- Secundair medium zorgt voor transport: water-glycol-oplossing, zoutoplossing of CO2
- NH3 blijft beperkt tot in de machinekamer.

Over gebuikte producten...

Toekomstperspectief (ammonia 21)

ECONOMY & MARKETS

- What are the key markets for ammonia today?

Industrial Refrigeration: Today, ammonia remains the most cost-effective and energy-efficient option for all types of industrial equipment. In fact, R717 makes up 15% of the total refrigerant market. R717 is expected to remain the preferred choice for large installations once ozone-depleting substances will be ruled out under international agreements. In the US and Canada ammonia is well regulated and enjoys a wide-spread use. In Europe, R717 has been widely adopted for industrial refrigeration in the UK and Germany but is more tightly regulated in France, Belgium, the Netherlands and Italy, and it is consequently less common. It is the most common alternative to HFCs for larger systems in Scandinavia, mainly as a result of restrictions and taxation on greenhouse gases. First installations in Australia have proved the efficiency of R717 plants. As a most recent example, ammonia freezes 6000 head of lamb every day in one of Australia's largest meat processing companies, being capable of freezing 1610 bulk packed export meat cartons with a 24-hour turn around.

Commercial Refrigeration: The use of ammonia in cascade supermarket refrigeration systems is growing, especially in countries with stringent limitations on the use of HCFCs and HFCs, such as Scandinavia.

Chillers: Although the use of R717 is still limited, this market is expected to grow. As a most recent example, a central ammonia chilling plant provides continuous supply of hot and chilled water for heating and air conditioning to Terminal 5 of London's airport Heathrow.

Heat pumps: R717 has been applied in medium-size and large capacity heat pumps, mainly in Scandinavia, Germany, Switzerland, and the Netherlands.

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R134a chillers

YK Centrifugal water cooled

Chiller air cooled

Centrifugal
magnetic bearing

Chiller / Screw
watercooled
with VSD

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Natural refrigerant Chillers

PAC recip NH3 with VSD
100 to 1400 kW

PAC screw NH3
200 to 6000 kW

ChillPAC recip NH3
with VSD
200 to 1400 kW

SabLight screw
with VSD
Propane to 400
kW

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- Intro in ecodesign
- F-gas : York's point of view
- Characteristics of Ammonia
- Chillers using both refrigerants with their pro's
- Examples of installations
- Conclusion

Atic
for HVAC professionals

Installation Industrial Refrigeration & HVAC

IMEC

- 1 x 2.6 mW chiller
- + 2 x 4 mW chiller

Brussels airport

- 3 YK's 1200 kW at -6.6°C
- Exchange Ciat units

Ammonia recip installations : split and chillpac watercooled

Installation Industrial Refrigeration & HVAC

Ardo

- **4 x CXV 643**
- **2 x SAB 355 + 2 x SAB 283**
- **3 mW 4-stage -40°C (Tevap) +30°c(Tcondens) : vegetable freezing tunnels**
- **possible extension : 9 mW compressorcooling in 3 phazes**

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Bottom Line…

1. Energy consumption should be concern number 1, not the choice of refrigerant
2. Strong lobbying from chemical industry to push HFO refrigerants
3. Per F gas regulation, there is no ban or threat of ban on R134a or R410a
4. In case (very unlikely) there be any limitations in the future regarding the use of R134a a safe blend (A1) can be proposed as a retrofit option
5. Ammonia is a great efficient refrigerant (especially under -10°C) but remember higher cost compared to R134a solutions under HVAC conditions
6. Recall safety issues and regulations for both NH3 and A2L fluids

From a global warming perspective we should push the solution that offers the best LCCP for a given price without necessarily following the fashion of ultra low GWP

Johnson Controls

Questions…?

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