



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Bosnia and Herzegovina

**Ministry of Foreign Trade and Economic Relations
Sarajevo, Bosnia and Herzegovina, 09-10 jul. 2019**

**WORKSHOP ON KIGALI AMENDMENT,
ALTERNATIVE TECHNOLOGIES, ENERGY EFFICIENCY
IN COOLING SECTOR AND SAFETY STANDARDS
Overview of alternatives/natural refrigerants
in different applications
Standards and safety aspects of natural refrigerants**

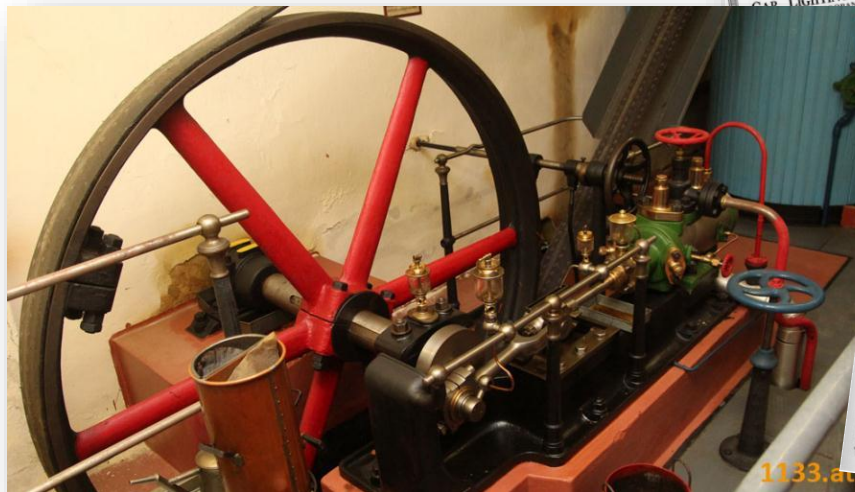
MAIN DRIVERS?

- **Regulation EN 517/2014**
- **(Leak detection, Training, Reporting)**
- **Phase down**
- **Price**

- **CUSTOMERS!!!!!!**

Best practice special: Refrigeration plant in Vienna, Austria

Operating from 1904 to 1997
Refrigerant: Carbon Dioxide
Testing Pressure 200bar
Operating Pressure 60bar
COP 3,36



PROPANE
"The Odorless Safety Refrigerant"
PROPANE (C₃H₈) possesses many points of superiority over Ammonia and other refrigerants.
It can be substituted for Ammonia in any compression plant without changing the operation.
At atmospheric pressure the boiling point is -42° F.
It is a neutral chemical, consequently no corrosive action occurs.
It is a better defrosting agent than ammonia and should occasion require, the engineer can work in its vapor without inconvenience.

Gas Lighting and Power Co.
NEW YORK



THE Old Swimmer's Hole has cooled many a kid's streaming eyes and "NATIONAL" Ammonia We say "fevered brow" there's nothing calculated to make the operator of an ice refrigeration plant more feverish than not to get the temperatures he wants.

"NATIONAL" in the plant and the comment. Can he had in a 150-lb., 100-lb., and 50-lb. cylinders from factory locations or 57 conveniently located stock points—there's one near you. List on request.

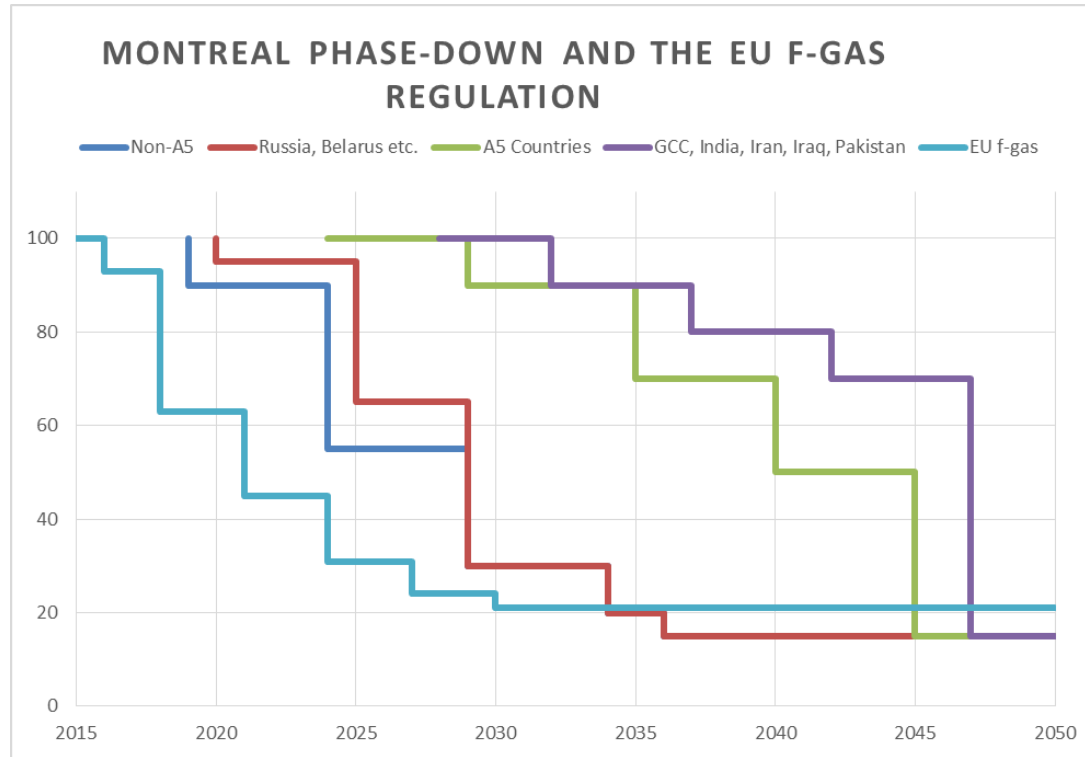
NATIONAL AMMONIA DIVISION
E. I. du Pont de Nemours & Co. (Inc.)
3600 N. Broadway, St. Louis, Mo.
Empire State Bldg., New York, N. Y.

Frankford P. O., Philadelphia, Pa.
235 Second St., San Francisco, Calif.

CO₂ REFRIGERATION
CARBONIC SAFETY SYSTEM
MEANS BEST
1902 U. S. PAT. OFF.
IN REFRIGERATION

American Carbonic Machinery Co.
NEW YORK WILSON RAPIDS, WISCONSIN
CHICAGO
ST. PAUL
CINCINNATI
CLEVELAND
PHILADELPHIA
SAN FRANCISCO
LOS ANGELES
SAN DIEGO
ALBANY, N. Y.

CURRENT STATUS 2019

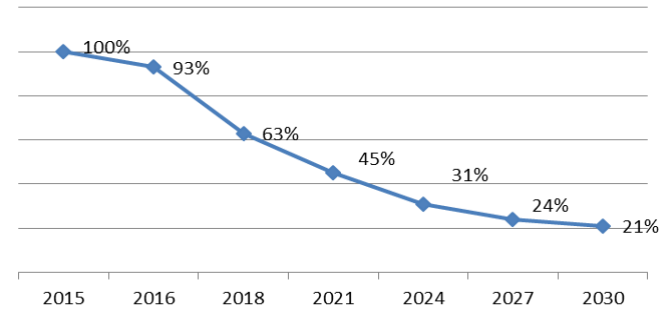


Impact of F-Gas in Spain

- Minimal reduction in allocations in 2016. Significant impacts in 2017 and 2018, which will lead to high price increases
- Spain also started Climate Protection actions by implementing **Special Tax**.

Gas	GWP	Total Price per Kg Sept 18 (€)	Breakdown of prices (€)	
			Cost of Gas	Cost of Taxes
R134a	1.430	60,52	44,02	16,50
R404A	3.921	116,49	57,67	58,82
R407F	1.824	57,69	30,32	27,37
R422A	3.142	102,44	55,30	47,14
R434A	3.245	123,21	74,53	48,68
R507A	3.985	123,08	63,3	59,78
R513A	629	44,84	35,4	9,44

Phase Down Target



Price of Gas has multiplied by 20 in the last 10 years !!!

CONTAINMENT

Article 3

Prevention of emissions of fluorinated greenhouse gases

Leak checks

5t - <50t CO₂ equiv.

12 months / 24 months

50t - <500t CO₂ equiv.

6 months / 12 months

>500t CO₂ equiv.

leakage control system/ min 6 months

Leakage detection systems

Record keeping

Recovery

1994: phase out of R22,

Customer Supermarket chain

Leakages

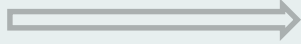
Uncertainty in investment

R404A, R134A?

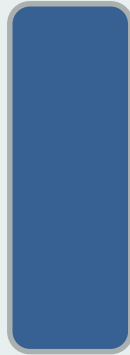
Product quality

Energy efficiency

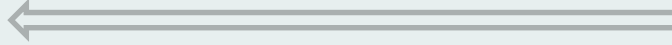
Condenser



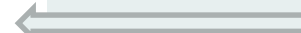
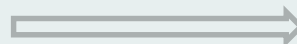
Machine room



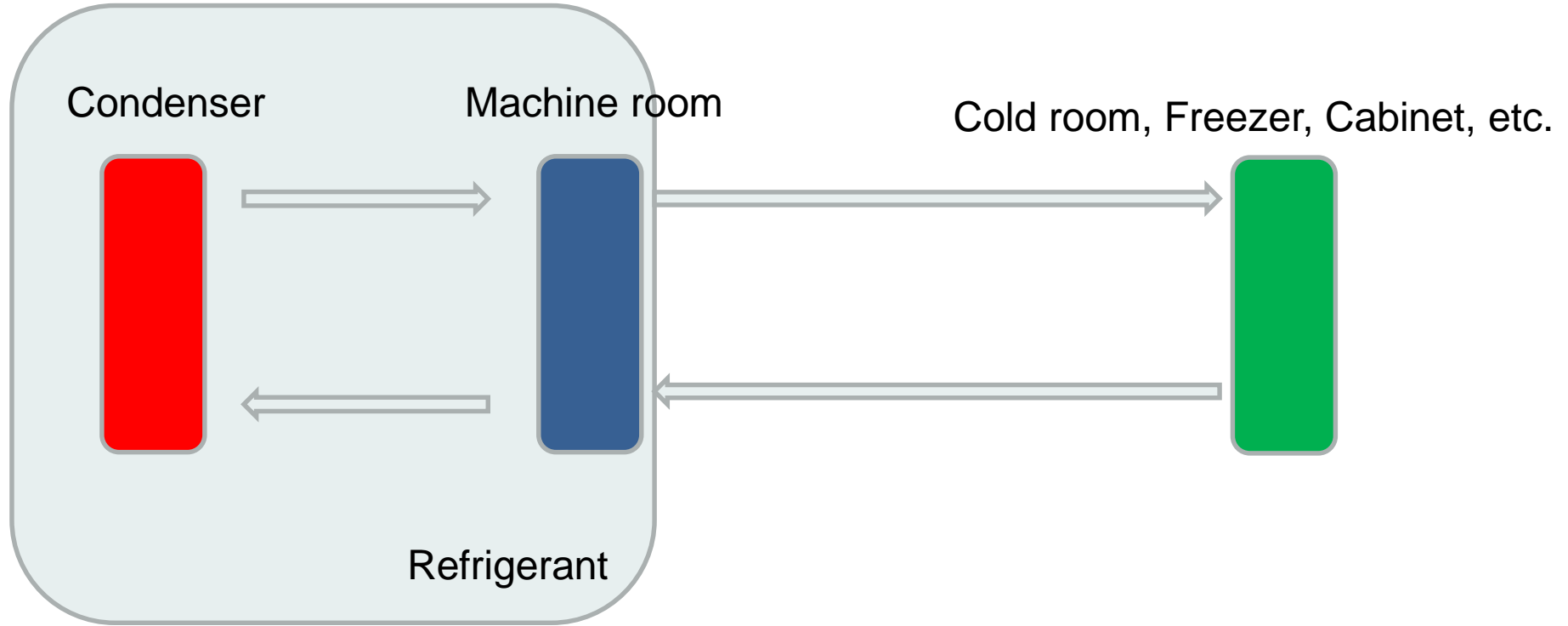
Cold room, Freezer, Cabinet, etc.



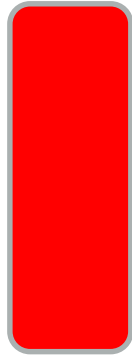
Refrigerant



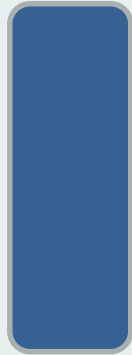
Refrigerant



Condenser



Machine room



Refrigerant



Cold room, Freezer, Cabinet, etc.



Thermodynamic Properties

Property		R134a	R404A	CO ₂	NH ₃
Enthalpie $t_0=0^\circ\text{C}$	[kJ/kg]	198,6	165,3	230,8	1262,2
Refrigeration capacity in context to mass flow $t_0=0^\circ\text{C}$	[kJ/m ³]	2867	5064	22546	4367

Ammonia has the largest evaporating enthalpy in context to mass flow.

AMMONIA the IDEAL refrigerant?

Combines following good properties:

- Good chemical properties
- Good thermodynamic properties
- Good physical properties
- No/neglectable influence to environment
- Good availability
- Good price

Ammonia is almost ideal....

Classification of ammonia

EN378-1

B2L

B = toxic

2 = low flammability

Electric must not fulfill the criterias of dangerous space (EN 378-3, cap. 6.3)

Ammonia – really bad?

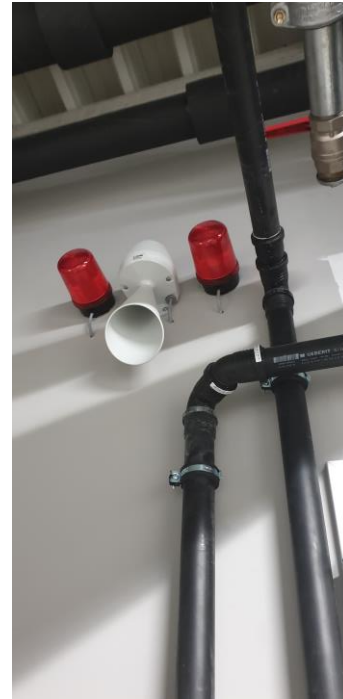
- flammable, in a narrow band (15 bis 28 Vol%)
- Explosiv, in high concentration (15 – 33,6 Vol%) with a high ignition temperature (651°C)
- toxic > 1500 ppm, but from 50 ppm on it has a warning affect!

Ammonia sensors

EN378-3, cap. 8.7, > 50 kg NH₃ sensors are a must!

- 500 ppm (<500 ppm) 1. Alarm, Ventilating system is started
- (1000 ppm main alarm)
- (10.000 ppm shut of)
- 30.000 ppm Electric system is shut down, Ventilation system is shut down









Inside and outside
of
an industrial
R717 / R744 plant.



CE declaration of conformity

EU-Konformitätserklärung :

Hiermit erklären wir, dass die Bauart der o. a. Anlage folgenden einschlägigen Bestimmungen entspricht:

- Druckgeräte-Richtlinie 2014/68/EU (DRL, PED)
- Maschinen-Richtlinie 2006/42/EG (MRL, MD)
- Niederspannungsrichtlinie 2014/35/EU (NRL, LVD)
- EMV Richtlinie 2014/30/EU (Elektromagnetische Verträglichkeit)

Angewandte harmonisierte Normen, insbesondere

- ÖNORM EN 378-1 bis Teil – 4, Kälteanlagen und Wärmepumpen Sicherheitstechnische und umweltrelevante Anforderungen soweit diese Hersteller und Lieferanten betreffen
- EN ISO 12100 T1 und T2 Sicherheit von Maschinen
- EN 61000-6-4 Elektromagnetische Verträglichkeit / Störaussendung
- EN 61000-6-2 Elektromagnetische Verträglichkeit / Störeffektivität
- EN 60204-1 Sicherheit von Maschinen / El. Ausrüstung von Maschinen

Angewandte nationale technische Vorschriften und Normen, insbesondere

- Kälteanlagenverordnung BGBl. Nr. 305/1969 i.d.F. BGBl. II Nr. 450/1994
- Maschinensicherheitsverordnung (MSV2010) BGBl. II Nr. 282/2008
- Duale Druckgeräteverordnung (DDGV) BGBl. II Nr. 59/2016
- ÖVE/ÖNORM E8001-1 Errichtung von elektrischen Anlagen bis 1000/1500V

CE

- Pressure equipment directive
- Machinery Directive
- Low voltage Directive
- EMV Directive Electromagnetic compatibility

Harmonised Regulations

- EN 378
- EN ISO 12100
- EN 61000-6-4
- EN 61000-6-2
- EN 6024-2

National (Austrian) regulations

Environment

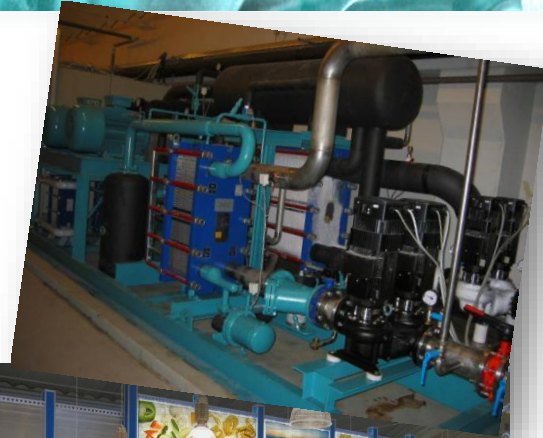
	R134a	R404A	CO2	NH3
ODP	0	0	0	0
GWP	1430	3920	1	0

Ammonia is the only double 00 refrigerant!



Medium refrigerating capacities: Supermarket refrigeration

Installed in: 2002
Capacity Range: 350 KW
Refrigerant: Ammonia
Filling amount 40kg/ 0,11kg/kW



Medium refrigerating capacities: Supermarket refrigeration

Installed in: 2008
Capacity Range: 50 KW / 2,7-4,7kW
Refrigerant:
Ammonia / Dimethyl-Ether (R723) / CO2
(R744)
Filling amount 32kg / 3,5kg



Small refrigerating capacities: Brewery Ottenbräu

Installed in: 2011
Capacity Range: 3 - 15 KW
Refrigerant: Ammonia / Dimethyl ether (R723)



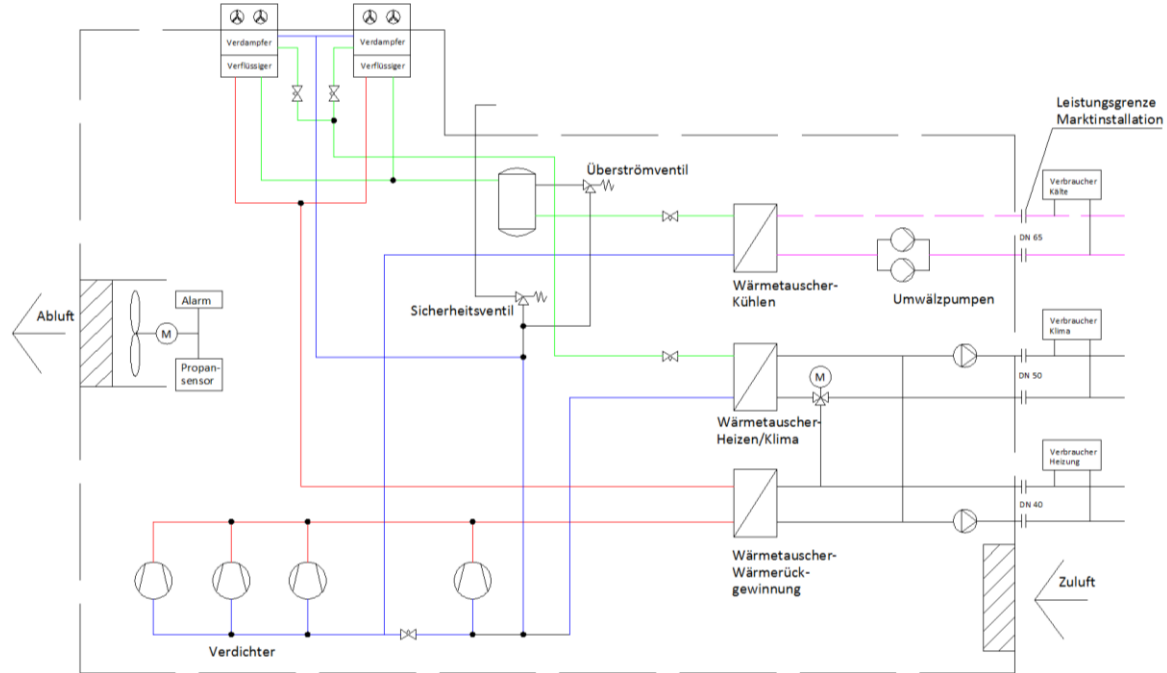
L Propan Supermarket

Type of facility: supermarket
Type of system: propane compact unit
System start-up: approx. 200 since 2010
Refrigerant capacity: 55 KW
Heating capacity: 73 kW
Refrigerant charge condenser: 92,3 kg
Evaporation temperature: -6°C
Condensation temperature: 45°C



 **thermofin**[®]
heat exchangers - GERMANY

Propan Supermarktanwendung



German supermarket chain cools and heats with integral systems



2008
Capacity: 50 KW / 2,7-4,7kW
refrigerant: R723 / R744
Filling amount: 60kg / 180kg



PIZZA & BAGUETTE FREEZER

Organic meat production



Organic meat production

Main datas:

Refrigerant: R290 26 kg

Refrigeration capacity: 2 x 180 kW

Secondary loop system -6° C/-2° C

ESEER: 3,44

Heat recovery: 2x42 kW @ 58/65

Refrigerant: R290 16kg

Refrigeration capacity: 1 x 160 kW

Secondary loop system 10° C/6° C

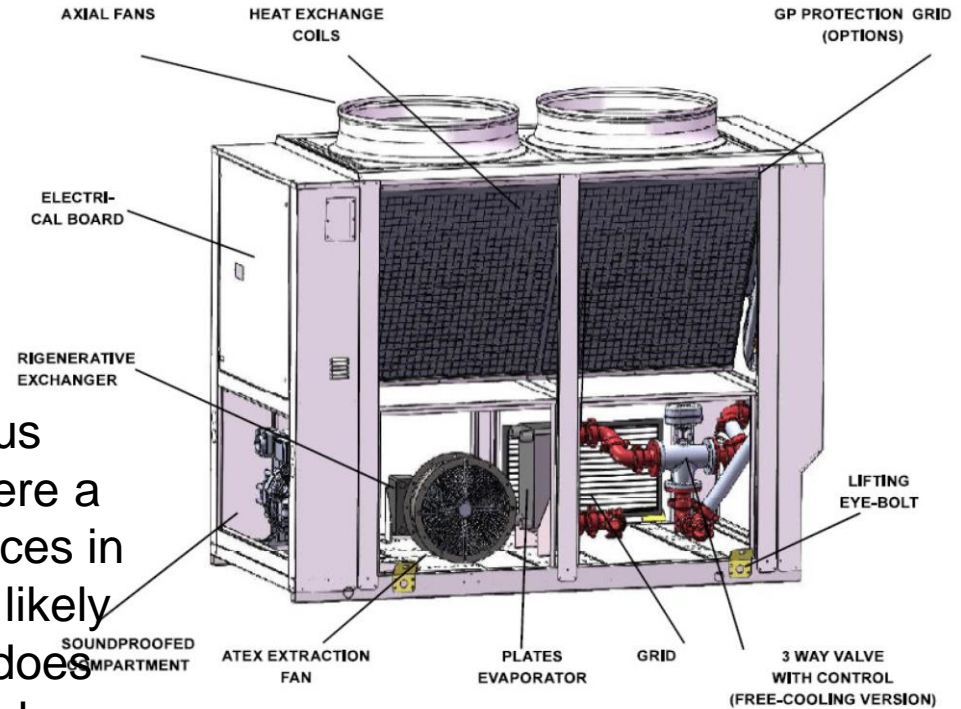
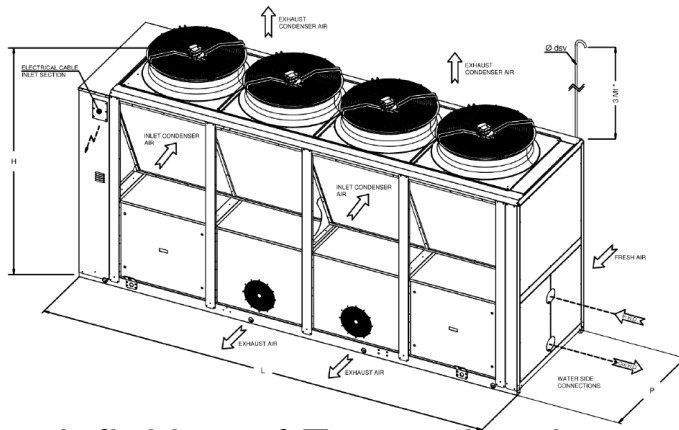
ESEER: 3,62

Heat recovery: 35 kW @ 58/65

Refrigerant: R744 @ to -35° C, tc -3° C

Refrigeration capacity: 22,2 kW

COP: 3,66



The definition of Zone 2 is a hazardous area classified as an atmosphere where a mixture of air and flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation, but if it does occur, will persist for a short period only.





2011
Refrigeration/heating capacity: 1900kW
refrigerants: R717 / R744
Filling amount 2900kg / 6000kg



Comparison Isentropenexponent

	R134a	CO ₂	NH ₃
Isentropenexponent κ	1,13	1,29	1,31

**R717 has higher compression end-temperatures.
!!! Heat recovery !!!**

Best practice special: Distribution Center

Complete supply with natural refrigerants:

Refrigerants:

R717 (Ammonia): 2000kW

R744 (Carbon Dioxide): 560kW

R717 (Ammonia) heat pump: 520kW

R744 2-stage heatpump

R290 (Propane): pressure control

Heat recovery:

800kW floor heating

400kW defrosting

AC: 140kW



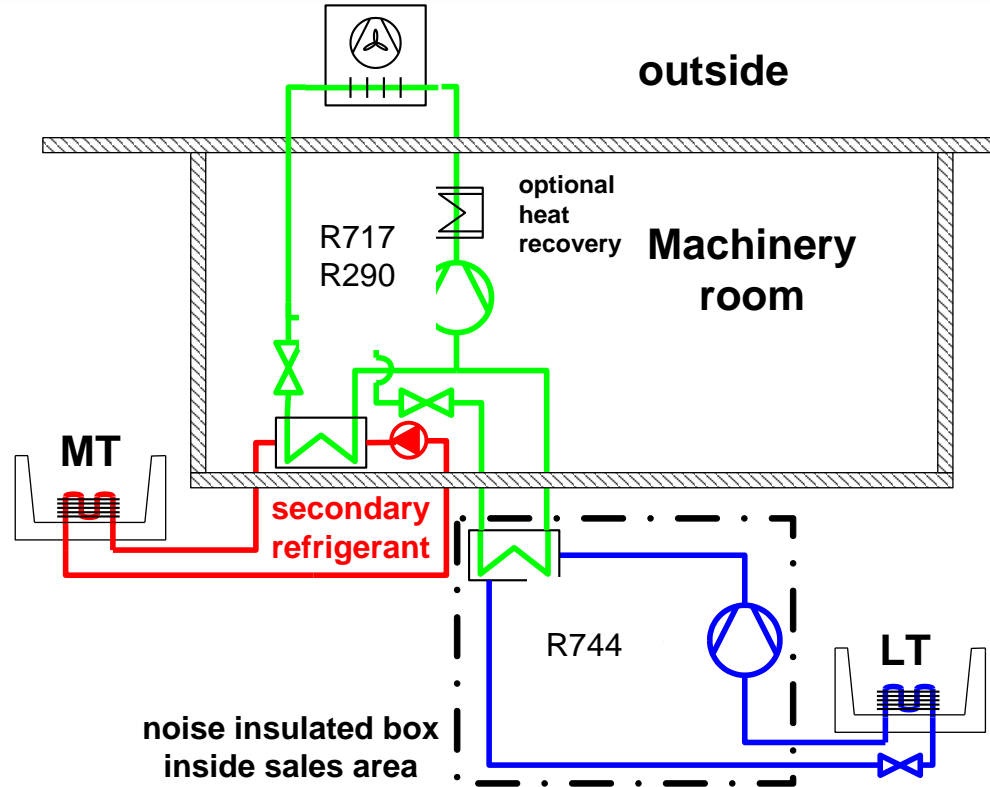








POSSIBLE SOLUTIONS



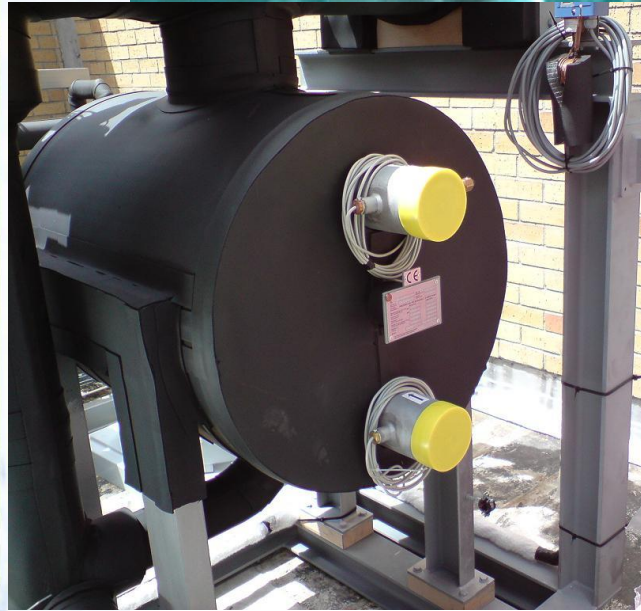


Johannesburg





Cape Town



- Situation in Johannesburg

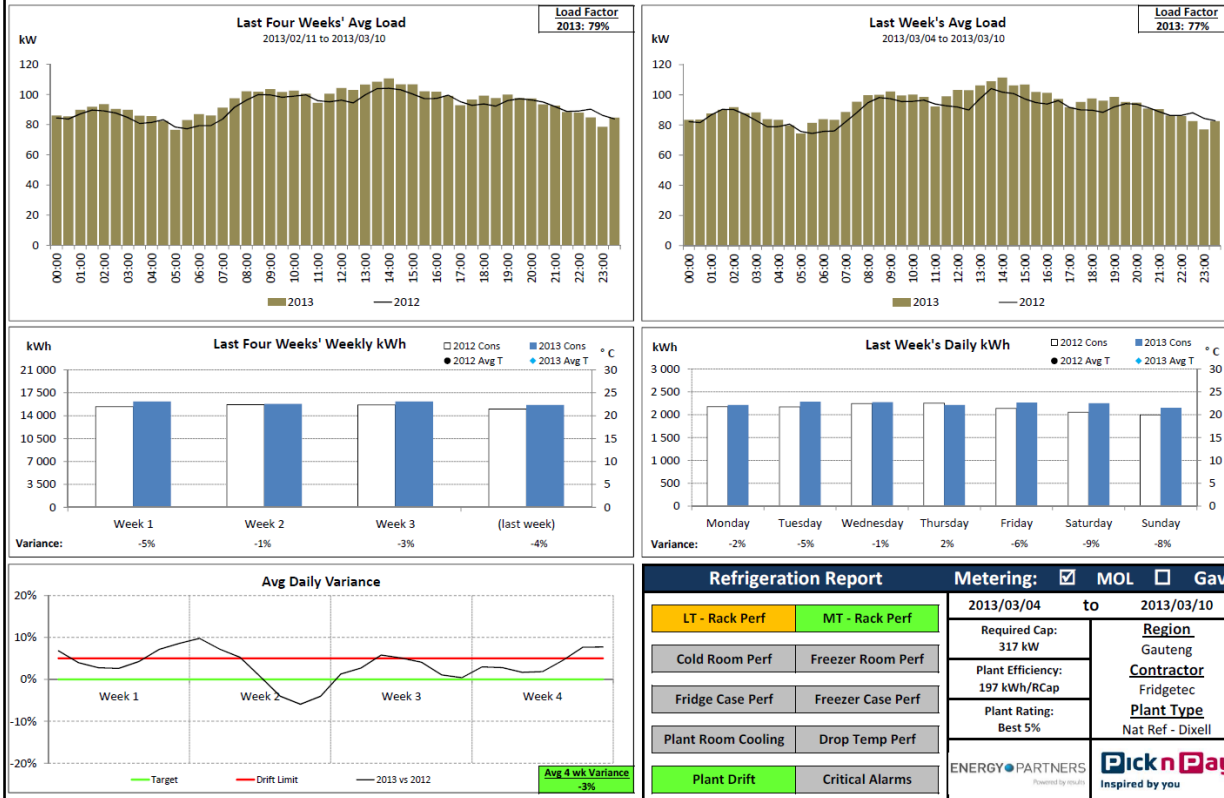
MAIN DATAS		
MT	140kW	$t_o = -12^\circ \text{C} @ t_c = +40^\circ \text{C}$
LT	60kW	$t_o = -12^\circ \text{C} @ t_c = +40^\circ \text{C}$
Refrigerant R22		1200kg
average loss		up to 80-240%

MAIN Datas of the new system		
MT	140kW	$t_o = -8^\circ \text{C} @ t_c = +38^\circ \text{C}$
LT	60kW	$t_o = -30^\circ \text{C} @ t_c = -3^\circ \text{C}$

- Situation in Cape Town

MAIN DATAS		
MT	kW	to =-15° C @ tc= +43° C
LT	kW	to =-32° C @ tc= +43° C
Refrigerant R22		1000kg
average loss		up to 80-240%
MAIN Datas of the new system		
MT	280kW	to =-8° C @ tc= +35° C
LT	37kW	to =-32° C @ tc= -3° C

PnP RANDPARK RIDGE: REFRIGERATION PERFORMANCE



*Variance not temperature corrected

Overview emission savings

Energy consumption reduction	19%	26%
Saved MWh /year	173	132
Saved t CO ₂ /year	161	122
Refrigerant emissions avoided t CO ₂ eq/year	234	340
Sum	396	462

Summary???

**Phase down?
NEW Challenges?**

SOLUTIONS? YES!

**THE BIG FIVE
NATURAL REFRIGERANTS!**



AIR



WATER



AMMONIA



HYDROCARBONS



CARBONDIOXID