SABROE FACTORY

Developments in High Temperature Heat Pumps

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Johnson Controls


SABROE
BY JOHNSON CONTROLS
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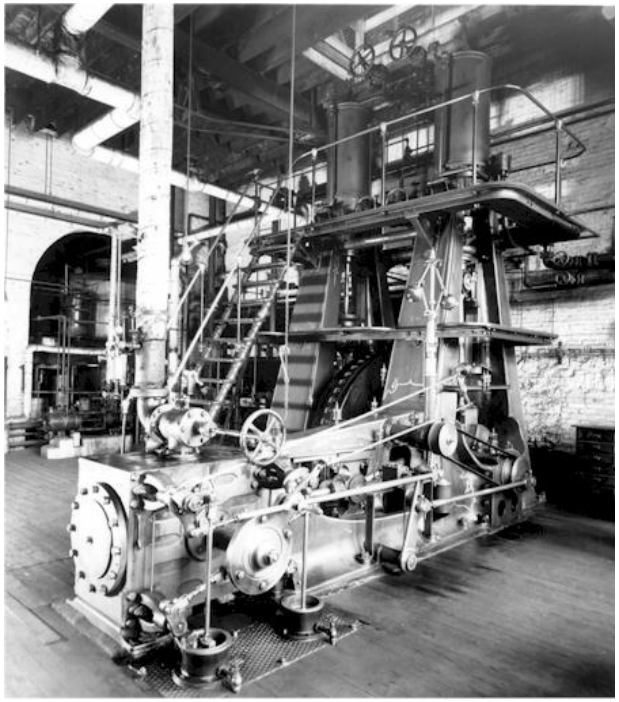
YORK
BY JOHNSON CONTROLS
Frick
BY JOHNSON CONTROLS
Gram
Refrigeration
STAL
REFRIGERATION
Johnson Controls

York, Frick & Sabroe, since 19th century



YORK
Since 1874

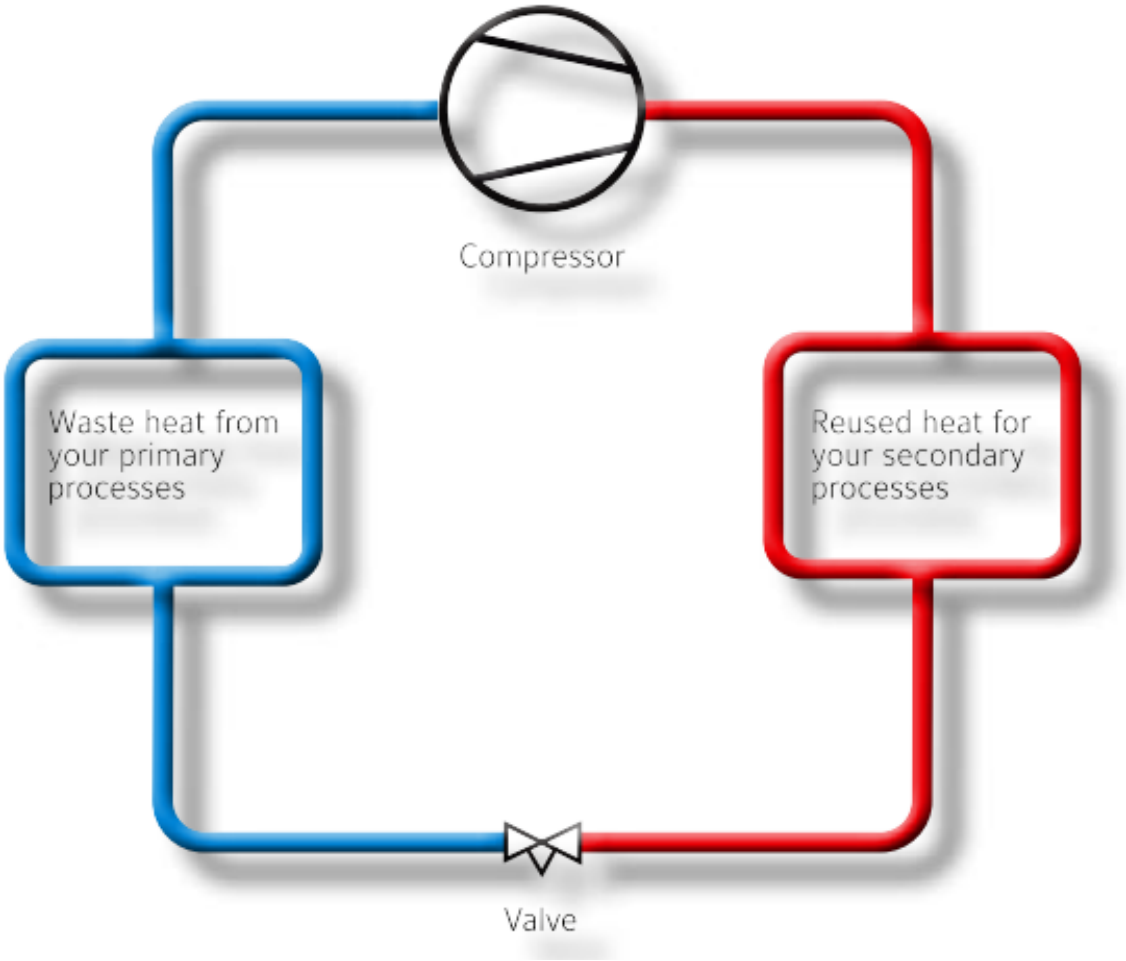
First Frick Compressor, built in 1885

- Two 12 x 18 cylinders
- Ammonia
- 50 RPM
- Steam Engine Driven

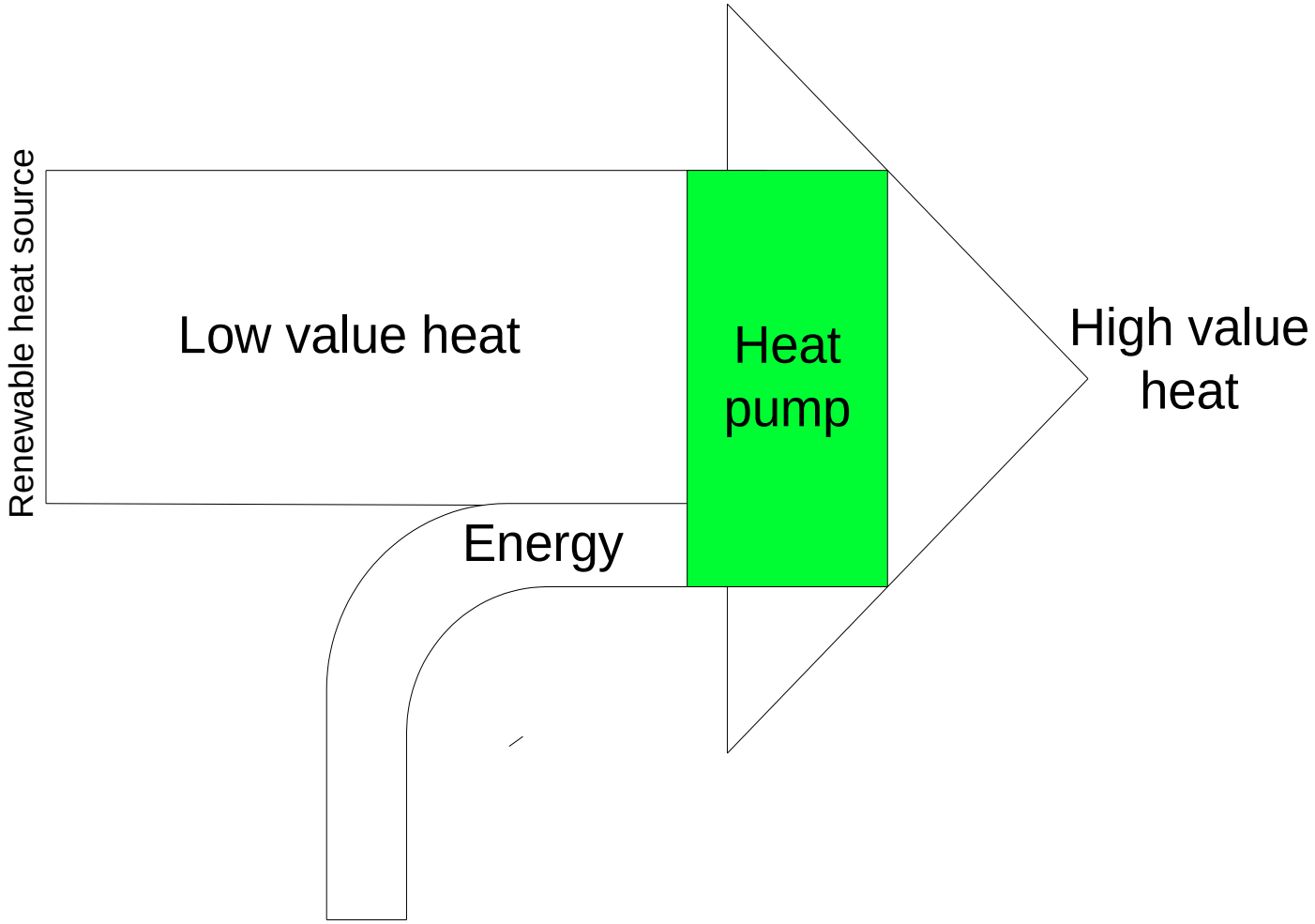
Sabroe CO_2-compressor, No. 2, built in 1897

- Capacity of 15 kW at -10/+25°C
- 90 rpm
- For a Danish dairy from 1897 to 1940

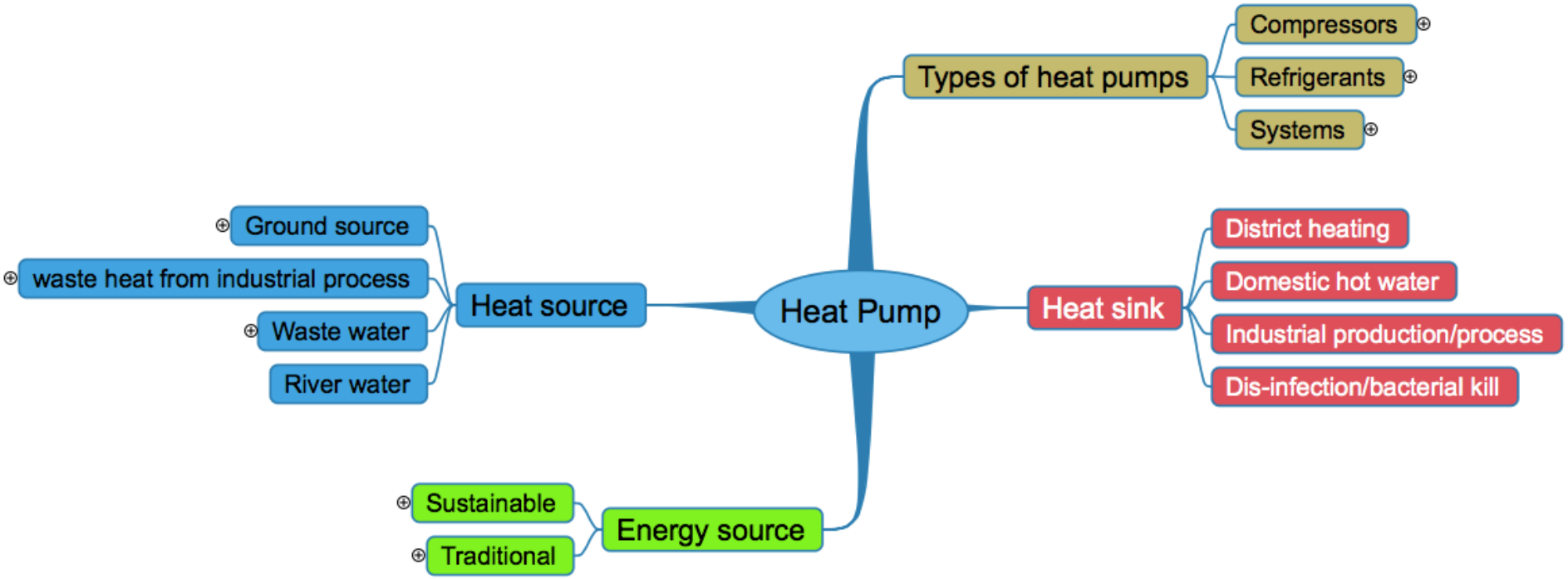
The Cycle


Compressor
Waste heat from your primary processes
Reused heat for your secondary processes
Valve

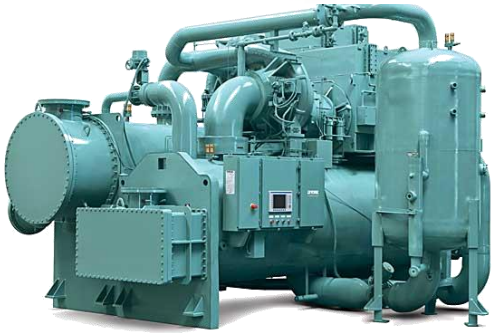
Heat pump technology is defined as sustainable

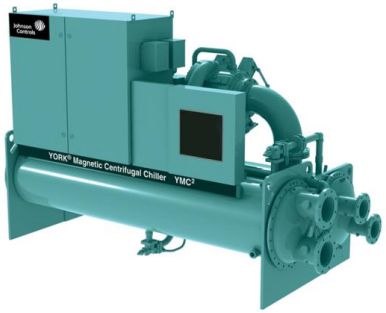


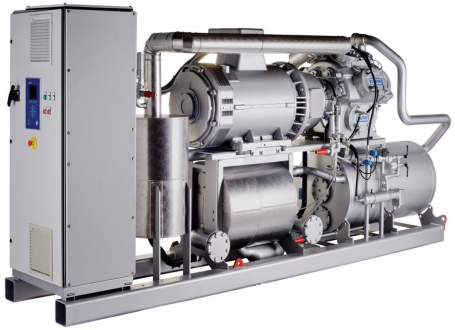
Heat Pumps


Heat Pump
Types of heat pumps
Compressors
Refrigerants
Systems
Heat source
Ground source
waste heat from industrial process
Waste water
River water
Heat sink
District heating
Domestic hot water
Industrial production/process
Dis-infection/bacterial kill
Energy source
Sustainable
Traditional

Heat Pump solutions







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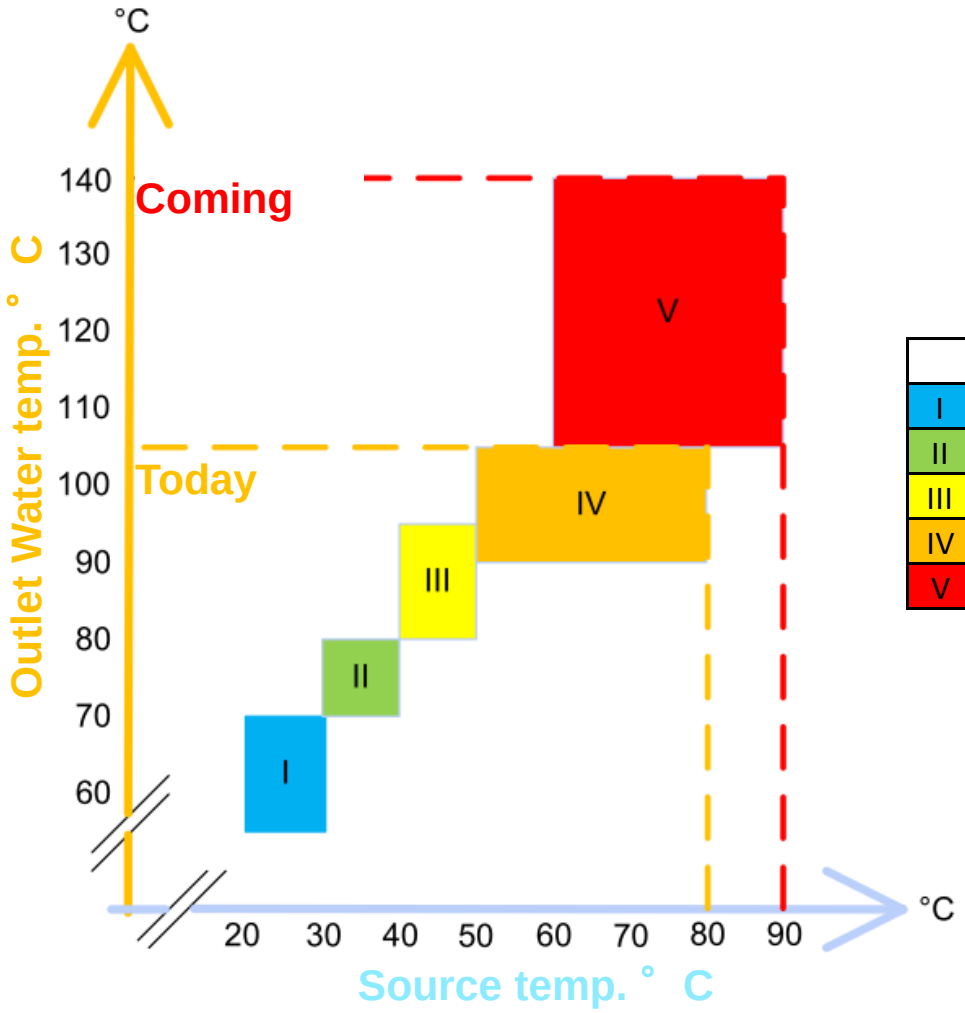
Johnson Controls Heat Pumps solutions overview



	Compressor Technology	Refrigerant
I	Scroll, recip, screw	R717, R134a, R410A
II	Recip, screw	R717, R134a
III	Screw, centrifugal	R717, R245fa
IV	Centrifugal	R245fa
V	Centrifugal	R718

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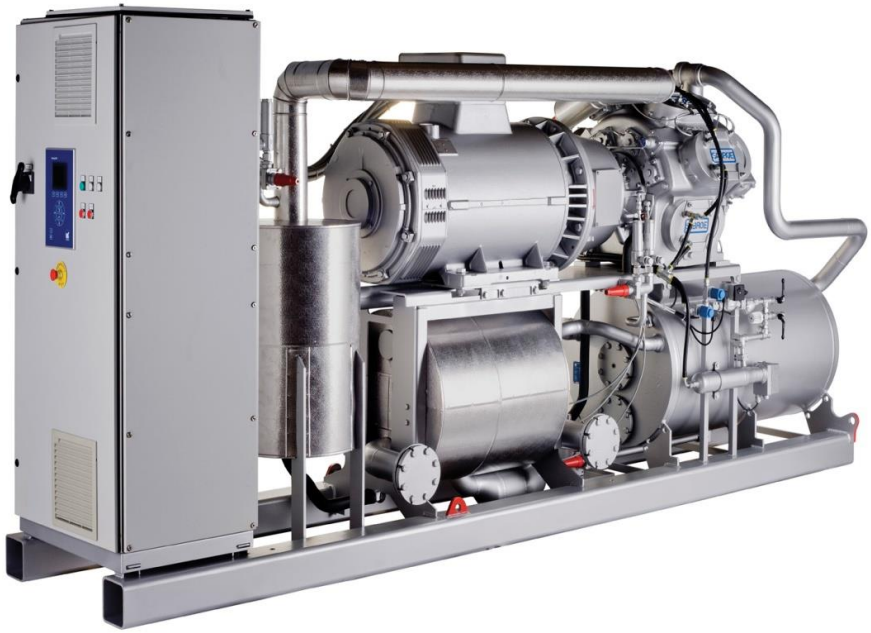
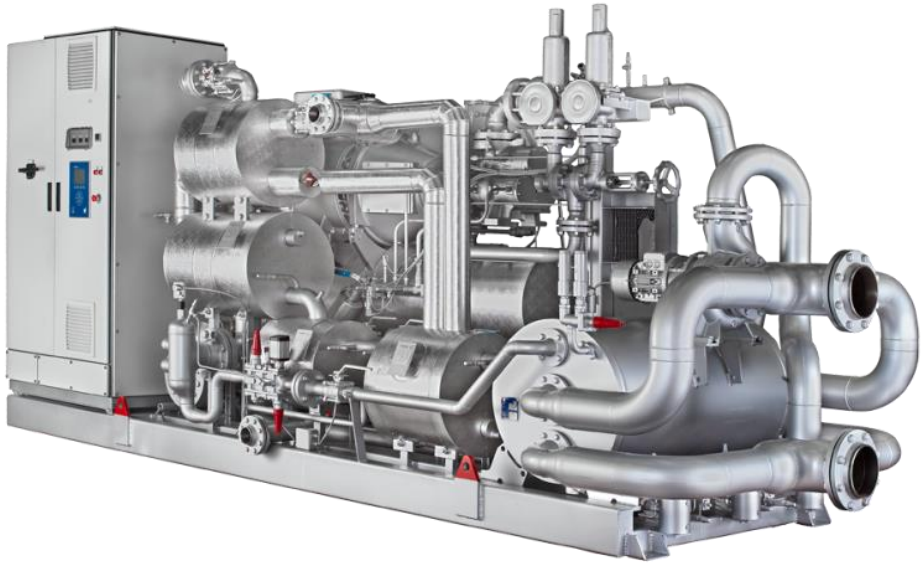
Heat Pump solutions



HeatPAC Recip

variable-speed drive
R717 (max. 48 kg charge)
Hot water up to **70° C**
Heating capacity up to 1200 kW at 40° C source

Heat Pump solutions



HeatPAC Screw

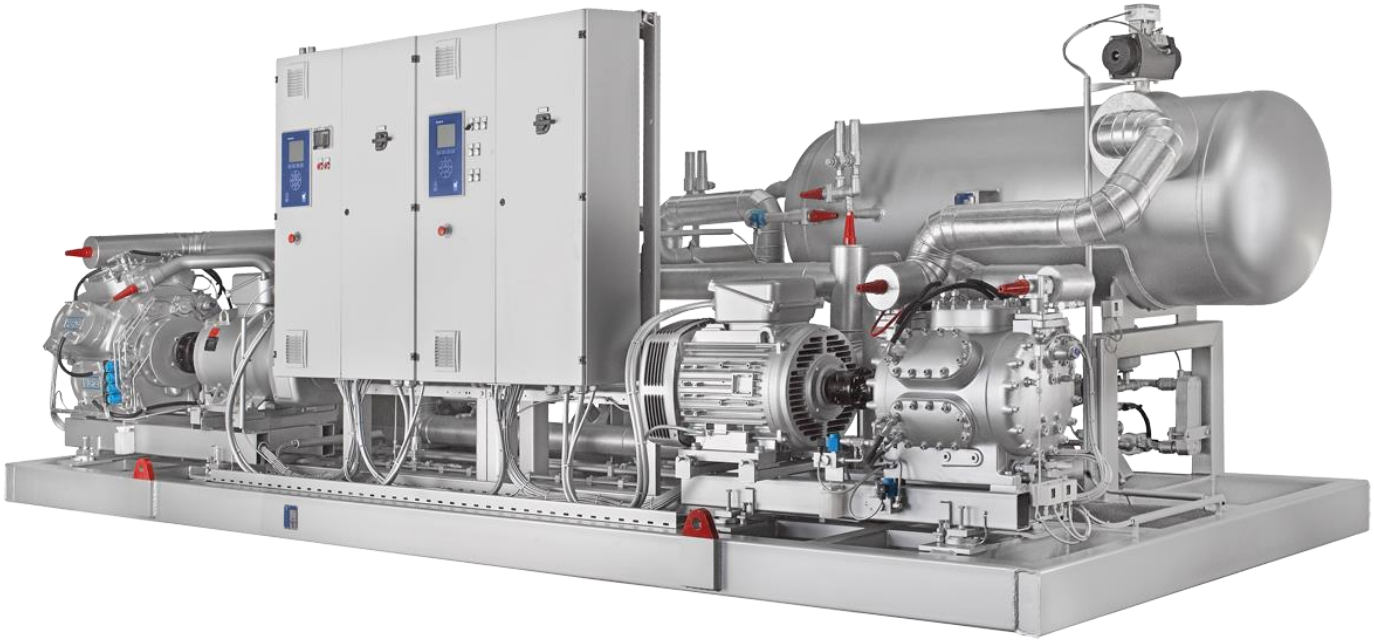
variable-speed drive

R717

Hot water up to **90° C**

Heating capacity up to 1600 kW at 40° C source

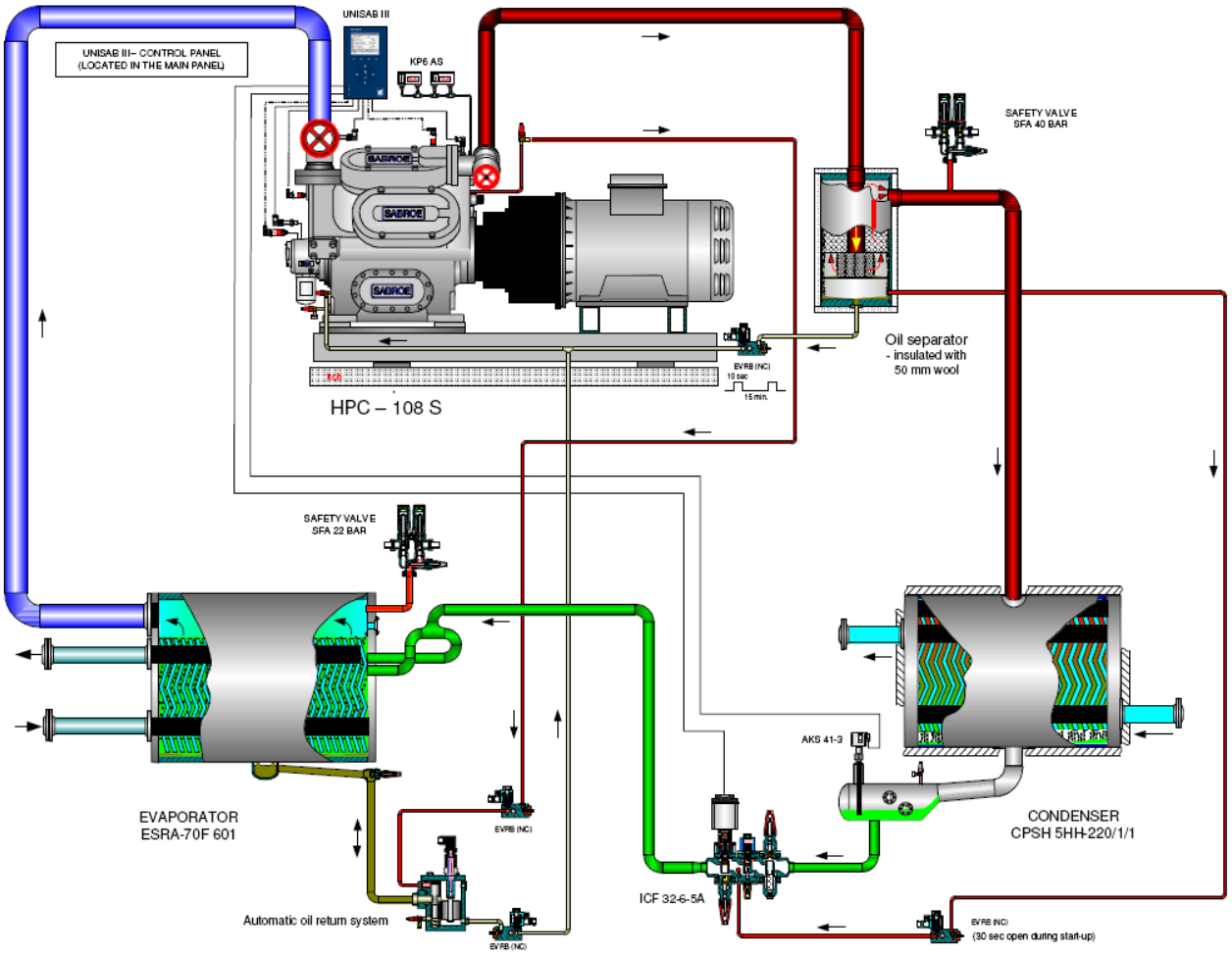
Heat Pump solutions



HeatPAC Custom

Two-stage cascade
variable-speed drive
R717
Hot water up to 90˚ C with screw
Hot water up to **70˚ C with recip**
Heating capacity up to +3000 kW at 40˚ C source

What is a HeatPAC?

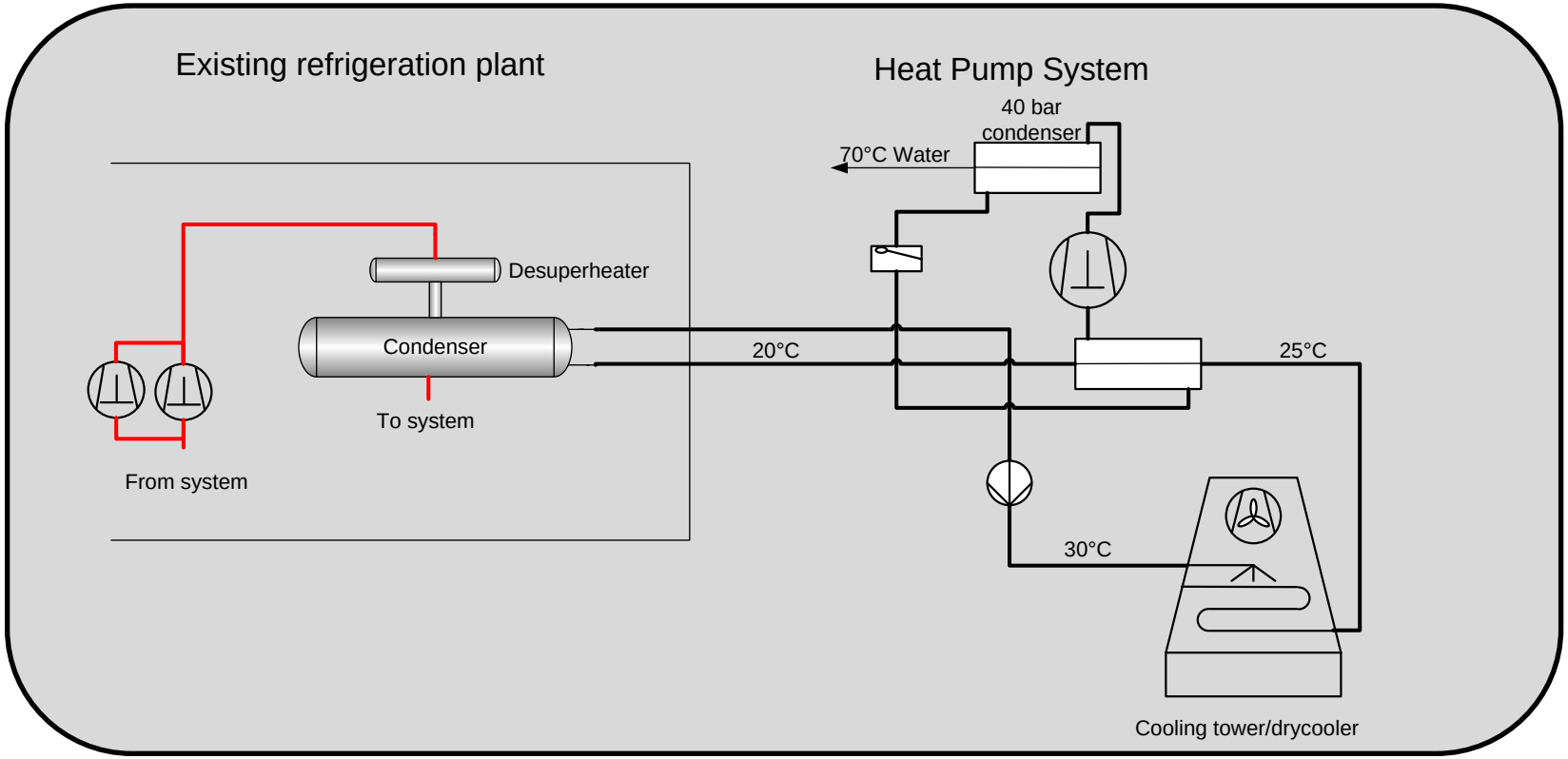


Heat from cooling tower/dry cooler principle

Connect to cooling tower/dry cooler water side

Pro: Simple installation – shut down of refrigeration plant not necessary

Cons: Not as efficient as direct suction – or cascade.

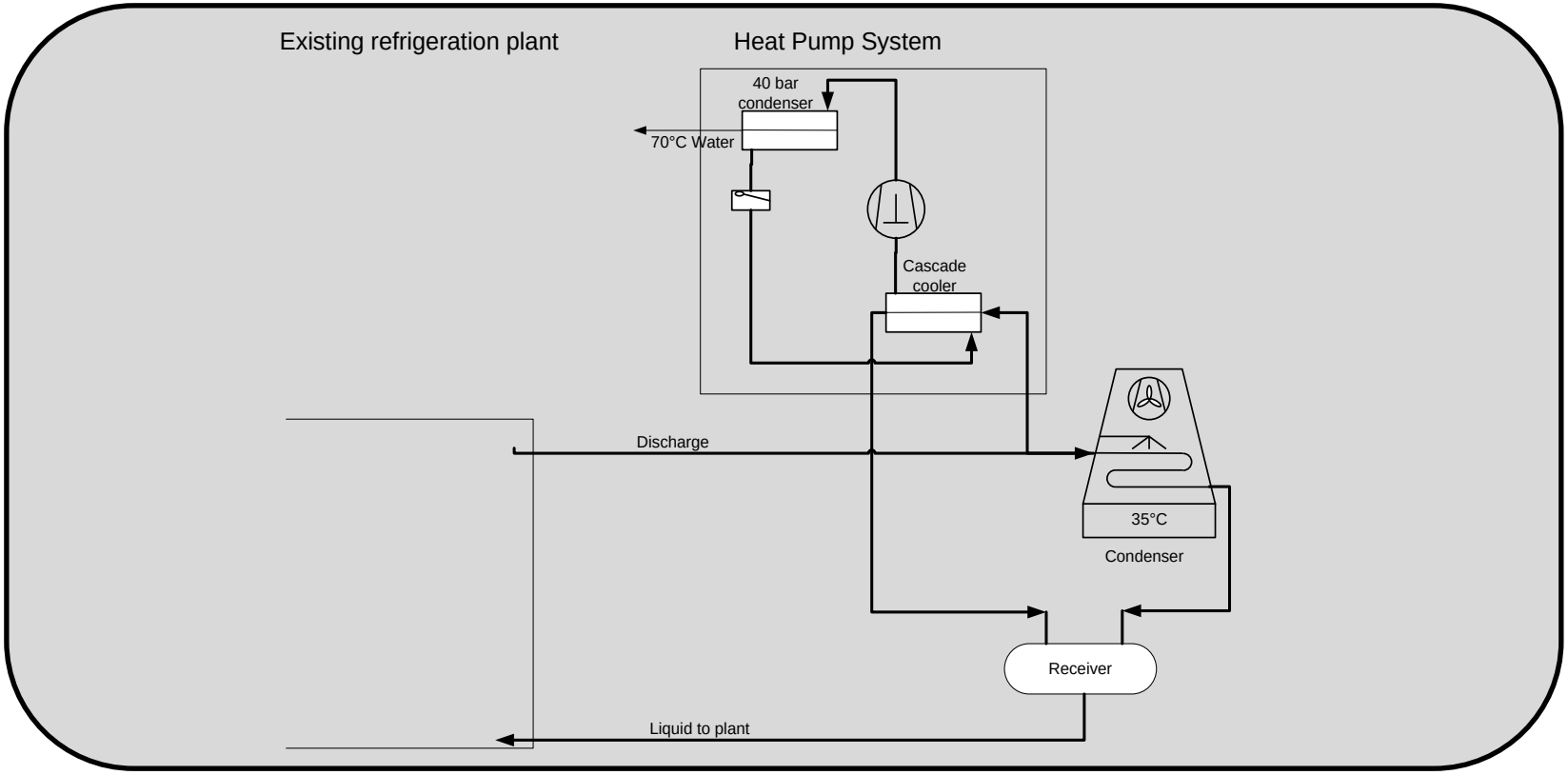


Heat from cooling tower/dry cooler principle

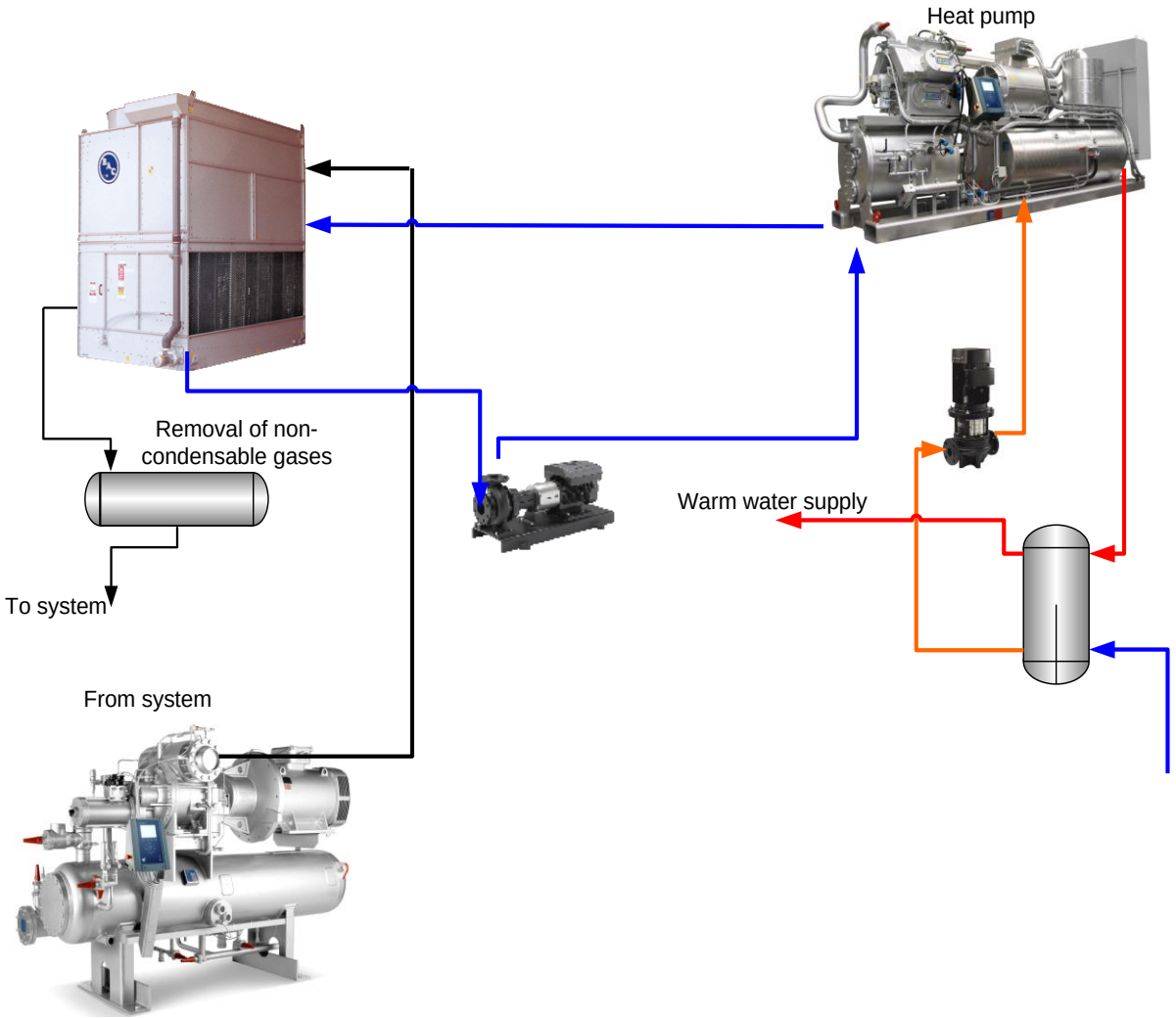
Connect with cascade exchanger to refrigeration curcuit

Pros: Higher efficiency than water solution. No direct contact between circuits (oil).

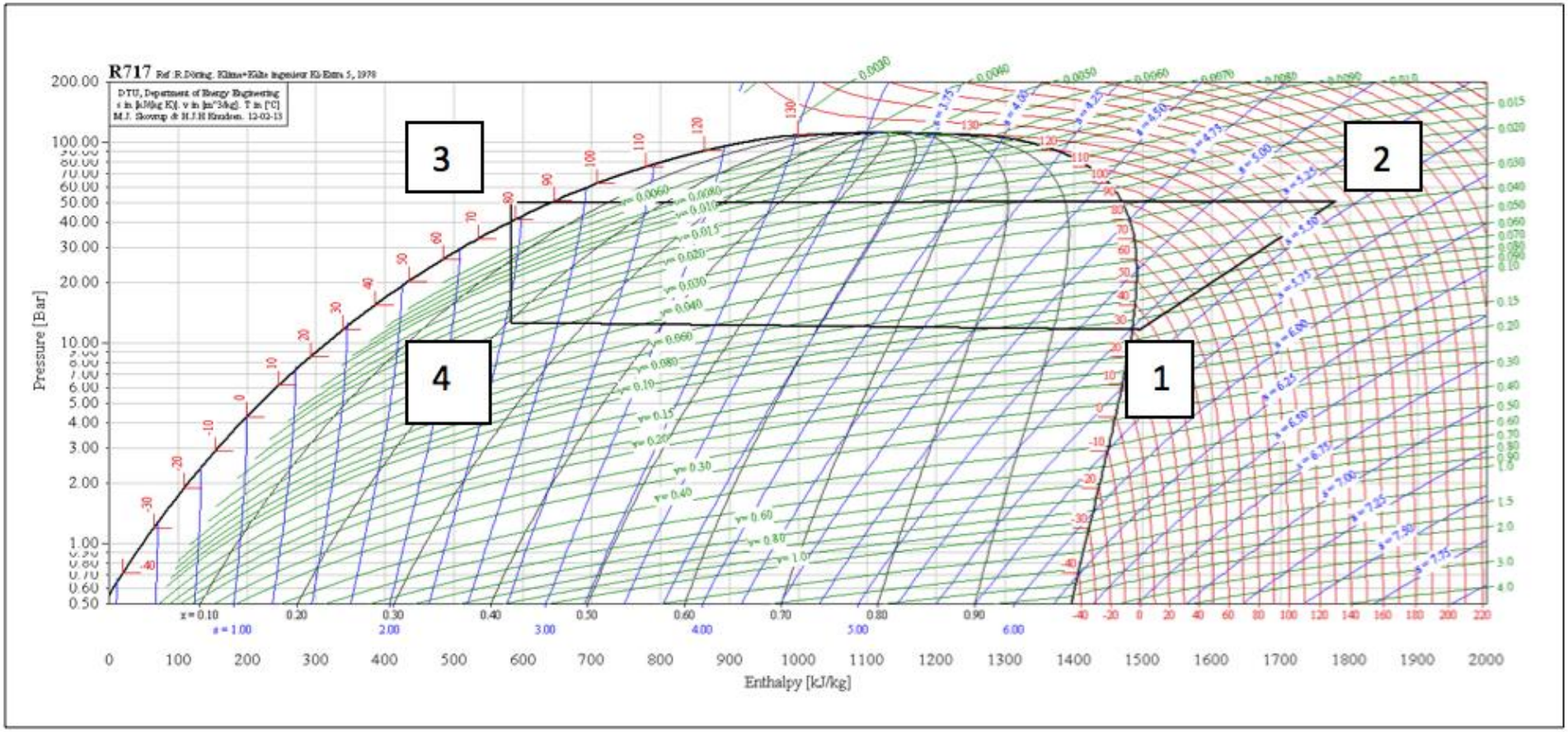
Cons: More complex installation. Requires cut-in on existing refrigeration curcuit



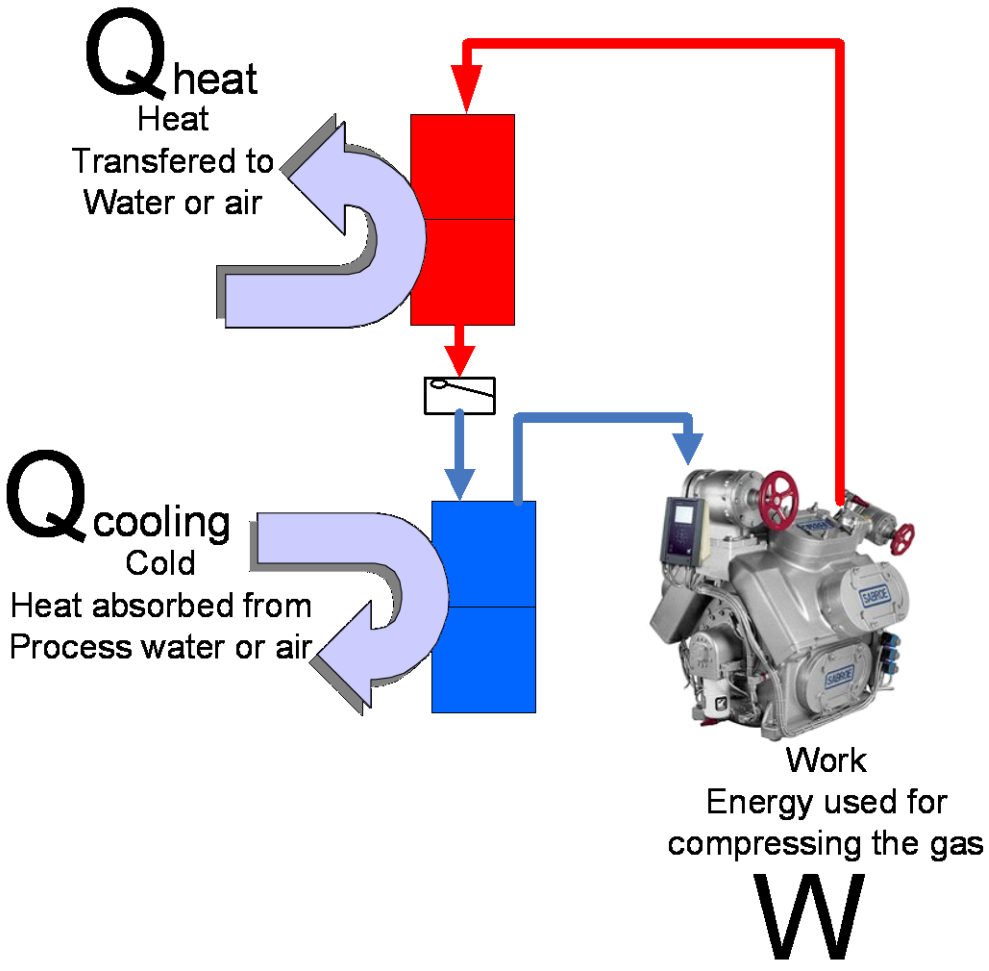
What can a system can look like?



Efficiency



Efficiency in an industrial process



COPcool= (h1-h4)/(h2/h1)

COP_{HP} = (h2-h3)/(h2-h1)

COPcooling	3,18
COPheating	4,18

COPcombi	7.35

From another system we know

Water	6,716.16	€/year
Chemicals	1,210.40	€/year
inspection	0.00	€/year
Saving on tower	**7,926.56**	**€/year**
Net Energy savings	33,115.28	€/year
Total savings	**41,041.84**	**€/year**
Aprox price	80,000	€
ROI	1.95	**Year**

Some examples

NL projects: Orbis Hospital, Sittard (2007)
Seasonal thermal storage (ground) using Sabroe & YORK

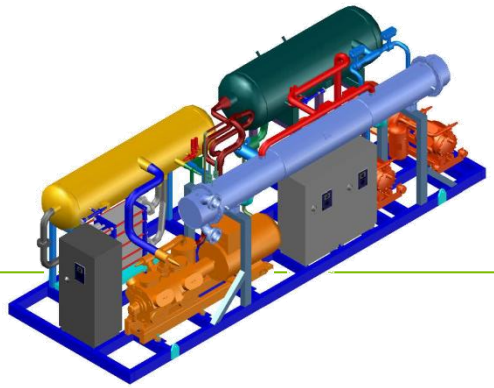
Make:	1x Sabroe	1x YORK	1x YORK
Type:	Screw - PAC193S-R	Screw – YN	Centrifugal – YK-R
Refrigerant:	Ammonia	R134a	R134a
Heating capacity:	1234 kW	1251 kW	--
Cooling side Tin/Tout:	14 / 6 °C	14 / 6 °C	--
Heating side Tin/Tout:	32.5/ 53 °C	32.5 / 53 °C	--
COP Heating:	4.6	4.1	--
Cooling capacity:	1197 kW	1000 kW	1690 kW
Cooling side Tin/Tout:	18 / 10 °C	18 / 10 °C	18 / 10 °C
Heating side Tin/Tout:	27 / 35 °C	27 / 35 °C	26 / 34 °C
COP Cooling:	5.8	6.4	6.3

NL projects: District heating Delft (end 2012)

Heat recovery from cleaned waste/sewer water, AWZI Harnaschpolder.

JCI installed a factory assembled two-stage HeatPump based on Sabroe reciprocating compressors (Low stage: 1x SMC112E / High stage: 2x HPO28):

- Sink water inlet/outlet temp. +50 / +75˚ C
- Source water inlet/outlet temp. +8 / +4˚ C
- Heating capacity 1220 kW
- COP heat pump = 3.4
- Ammonia charge = 200 kg
- Performance guarantee by JCI



NL projects: T30 - Energy/water savings FrieslandCampina (startup 2014)

Production site:	Domo, Beilen, producing baby food ingredients / nutritions
Heatpump capacity:	4 MW heatpump to produce hot water of 90 ºC
Heat source: from	Water around 45˚ C is available from production. It is removed milk by the Vacuum evaporation device before the air drying
Heat sink (useful):	Pre-heating the fresh air flow inlet into the spray dryer device by using water of 90 ºC
Difficulties:	Systems performance window: complex interaction / disturbances on input (heat source) and output (heat sinks)

Performance:

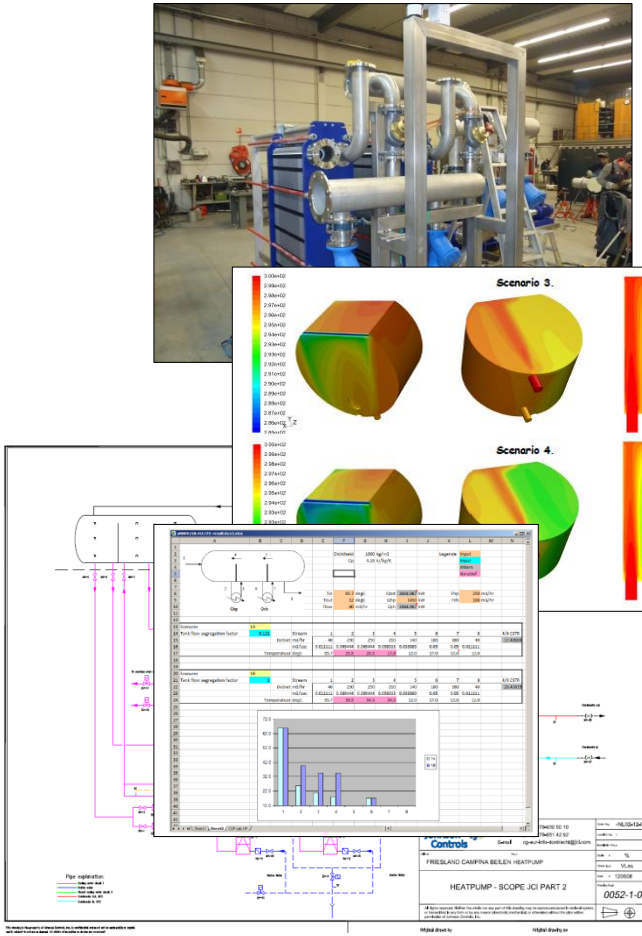
Sink water inlet/outlet temperature:	45 / 90˚ C
Source water outlet temperatuer:	12˚ C
Heating capacity, maximum:	+/- 4.5 MW
COP range heat pump:	3.0 up to 5.0
Ammonia charge:	3x250 + 2x60 kg

NL projects: T30 - Energy/water savings FrieslandCampina (startup 2014)

JCI branches are involved in:

Design / Engineering, JCI Dordrecht Netherlands
- Thermodynamics / hydraulics (optimized concepts)
- Review specifications, functional design control systems
- P&ID's, GA, construction & service manuals
- Project Management
- Supervision, startup & commissioning
- Service and after sales
- Assembly of heat exchanger- and pump skids (hydraulics according to FC welding specs)

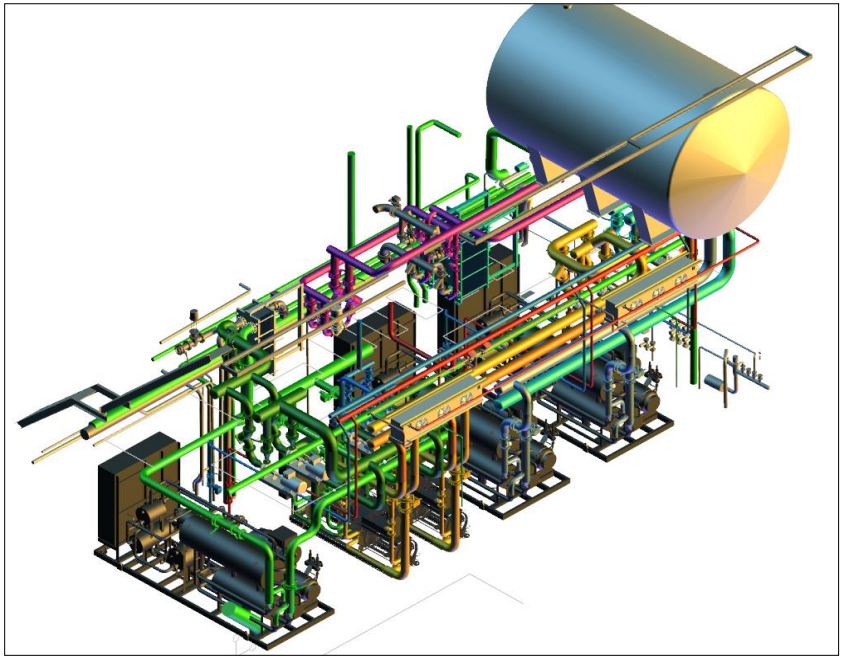
Manufacturing Sabroe, Holme Denmark
- Production & assembly of heatpumps
- End Of Line test; full load performance test

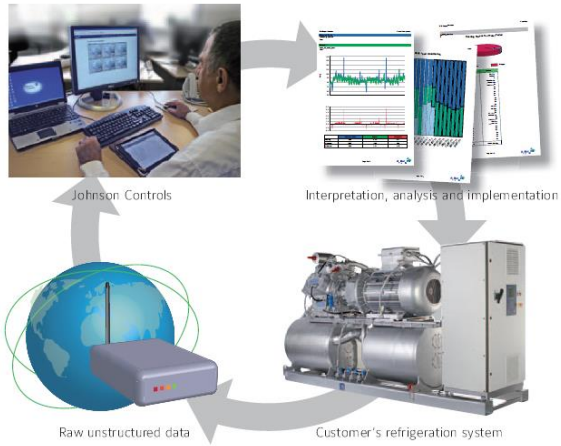


NL projects: T30 - Energy/water savings FrieslandCampina (2013)

JCI solution is based on standard ‘blocks’ (modular):

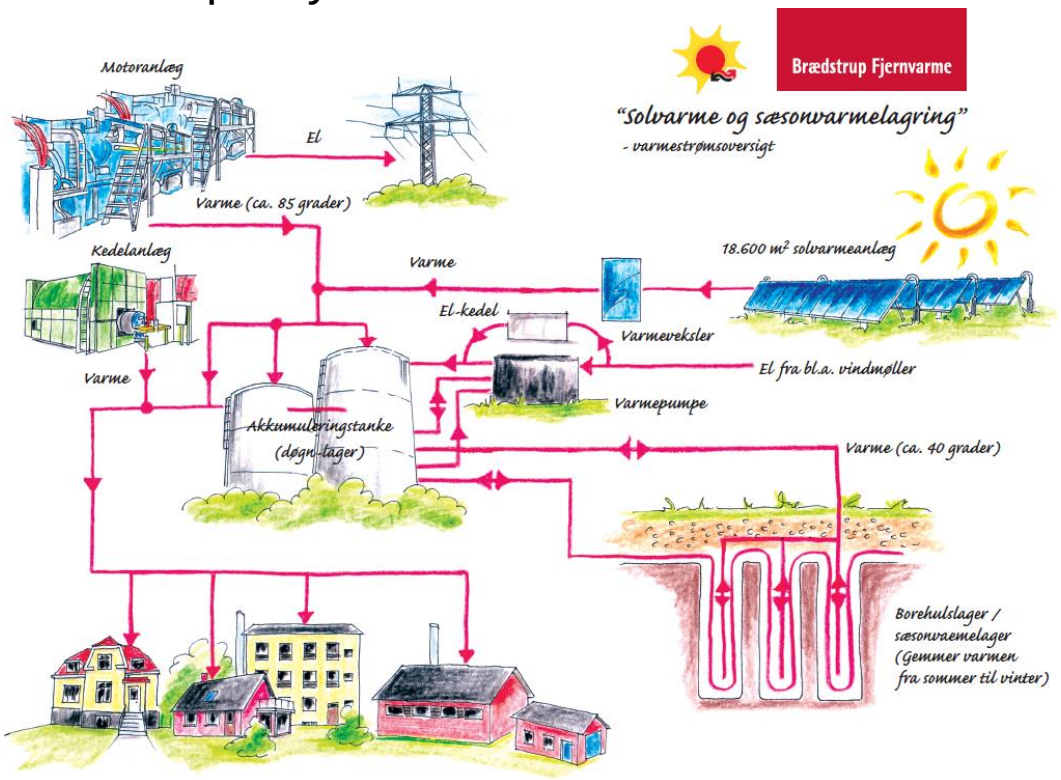
- ✓ 3x Sabroe HeatPAC157 with VSD (high temperature)
- ✓ 2x Sabroe ChillPAC112 (low temperature / chiller mode)
- ✓ Pump units, heat exchangers
- ✓ Advanced control system (Siemens PLC)
- ✓ Safety systems





District heating Bræstrup

Application: District heating
Place/site: Brædstrup, DK
Supply temperature: 72° C
Capacity: 1MW



Country	Pcs	Delivery	Segment
France	1	2011, September	Dairy
Denmark	1	2012, June	District heating
Denmark	3	2012, September	Paper
Netherlands	3	2012, October	Dairy

Conclusions

Conclusions

Heat pump technology is difined as being a sustainable technology

There are many sources and sink combinations possible

In industrial applications where you can use both the cooling and heat capacity the combined COP increases considerably

Recovering heat on the cooling water helps saving chemicals and water

Heat pumps enables recovery of heat and boosting supply temperature in remote parts of big district heating systems

With the modern district heating system with lower supply temperatures the losses are also reduced

References

HeatPAC's Europe

Country	End-user	qty	Description	Segment	Delivery
United Kingdom	MRSL	1	HeatPAC 28, VSD	Non food industry	16-Dec-10
United Kingdom	brewery	1	HeatPAC 28,VSD	Beverage industry	01-Aug-11
United Kingdom	Direct Table Foods	1	HeatPAC 24	Pork food	20-Dec-11
United Kingdom	MSRL	1	HeatPAC 104 S	Non food industry	18-Jan-12
United Kingdom	JCI Dublin/MRSL Vistakon	1	HeatPAC 28, VSD	Pharmaceuticals	17-Feb-12
United Kingdom	?	1	HeatPAC 108 S	Abattoir	07-Dec-12
United Kingdom	I I Ice	1	HeatPAC 106 S, VSD	-	10-Jan-14
United Kingdom	I I Ice	1	HeatPAC 106 S, VSD	-	10-Jan-14
Ukraine	DANONE / Sergey Slobodenyuk	1	HeatPAC 108 S	Dairy food	29-Mar-12
Switzerland	Tischmacherhof	1	HeatPAC 106 SR	Heat pump	27-Aug-10
Switzerland	Tischmacherhof	1	HeatPAC 106 SR	Heat pump	27-Aug-10
Switzerland	Iglenwiese	1	HeatPAC 24	Recidence	01-Nov-11
Switzerland	Iglenwiese	1	HeatPAC 104 SV, VSD	Recidence	01-Nov-11
Switzerland	Iglenwiese	1	HeatPAC 104 SV, VSD	Recidence	01-Nov-11
Switzerland	Kantonsspital Glarus	1	HeatPAC 106 SV, VSD	Hospital	10-Feb-12
Switzerland	Kantonsspital Glarus	1	HeatPAC 106 SV, VSD	Hospital	10-Feb-12
Switzerland	Flughafen Zürich - 2HBB0013	1	HeatPAC 106 SV	Non food industry	23-Nov-12
Switzerland	Affolter Lagerhalle	1	HeatPAC-106-S, R717	Contractors	28-Nov-12
Switzerland	EV Hagenholz	1	HeatPAC-106-S, VSD	Heat pump	15-Mar-13
Switzerland	Botanischer Garten - 2HBB0020	1	HeatPAC 26, VSD	-	17-Dec-13
Sweden	Sandvik Coromat AB	1	HeatPAC 108 S	Non food industry	15-May-08
Sweden	Sandvik Coromat AB	1	HeatPAC 108 S	Non food industry	15-May-08
Sweden	Norrmejerier, Burträsk	1	HeatPAC 104 S	Dairy food	14-Dec-12
Spanien	CampoFrio	1	HeatPAC 106 S	Cold stores	01-Nov-10
Spanien	CampoFrio	1	HeatPAC 106 S	Cold stores	01-Nov-10
Poland	FU Therm/Superdrob, P164130040	1	HeatPAC 108 S	Poultry food	28-Jan-11
Poland	FU Therm / Superdrob 1	1	HeatPAC 28	Poultry food	25-Feb-11
Norway	Forsvartsbygg Udvikling Vest	1	HeatPAC-SMC108L/HPC106S	Heat pump	04-Mar-09
Norway	Forsvartsbygg Udvikling Vest	1	HeatPAC-SMC108L/HPC106S	Heat pump	28-Nov-08
Norway	Kolsås Militærleir	1	HeatPAC 106 SR Reciptune	Heat pump	20-Apr-10
Norway	FATLAND OSLO AS	1	HeatPAC 28, VSD	Meat food	15-Apr-13
Ireland	MRSL	1	HeatPAC 28, VSD	Non food industry	17-May-13
Iceland	Höfn, Island - 9331690015	1	HeatPAC 26, VSD	-	15-Apr-13
Germany	Migros Gossau	1	HeatPAC 104 SR	Heat pump	09-Jun-11
Germany	KAH Hamburg - 3HBC0085	1	HeatPAC 24, VSD	Educational establishment	27-Jun-13
France	THIRIET	1	HeatPAC 108 S	Ice-cream food	31-May-11
France	MONDIAL FRIGO	1	HeatPAC 26	-	25-Mar-11
France	TRADIVAL	1	HeatPAC 108 S Cascade	Meat food	16-Sep-11
France	Bergerie de Lozère	1	HeatPAC 26, VSD, cascade	Meat food	09-Dec-11
France	RANOU	1	HeatPAC 108 S,R717	Cold stores	20-Apr-12
France	MONDIAL FRIGO	1	HeatPAC 104 S	Meat food	29-Jun-12
France	MONDIAL FRIGO	1	HeatPAC-104-S, R717	Contractors	20-Jul-12
France	MARIE SURGELES	1	HeatPAC 108 S	Cold stores	28-Sep-12
France	Triballat	1	HeatPAC 108 S	Dairy food	15-Nov-13
Finland	Nestlé, ISPAIljoki/P153230220	1	HeatPAC 108 S, VSD	Other food	16-Dec-11
Finland	Livite / Lahtian Lampopumppu	1	HeatPAC 28, VSD	Non food industry	10-Aug-12
Estonia	ARCE - Estonia	1	HeatPAC 108 S	Meat food	15-May-12
Estonia	ARCE - Estonia	1	HeatPAC 108 S	Meat food	15-May-12
Denmark	Novo Nordisk, Hillerød	1	HeatPAC 106 SR	Pharmaceuticals	05-Nov-10
Denmark	Novo Nordisk, Hillerød	1	HeatPAC 108 SR	Pharmaceuticals	05-Nov-10
Denmark	Korsholm Gartneri, Hinnerup	1	HeatPAC 108 S	Non food industry	28-Feb-12
Denmark	Korsholm Gartneri, Hinnerup	1	HeatPAC 108 S	Non food industry	28-Feb-12
Denmark	Korsholm Gartneri, Hinnerup	1	HeatPAC 108 S	Non food industry	28-Feb-12
Denmark	Korsholm Gartneri, Hinnerup	1	HeatPAC 108 S	Non food industry	28-Feb-12
Denmark	Vejen Varmeværk	1	HeatPAC-106-S, VSD	Non food industry	16-Nov-12
Denmark	Vejen Varmeværk	1	HeatPAC-106-S, VSD	Non food industry	16-Nov-12
Denmark	Fertin Pharma-YIT	1	HeatPAC 108 SV	Chemical /petrochemical	18-Mar-13
Denmark	DK Foods, Kjellerup	1	HeatPAC 28, VSD	Other food	25-Apr-13
Croatia	SARDINA, Postira, Croatia	1	HeatPAC 26	Fish food	18-Jan-13
Bosnia-Herzegovina	Soko Inzinjering/Modrica	1	HeatPAC 108 S, VSD	Chemical /petrochemical	17-Dec-13
Austria	?	1	HeatPAC HPC 108 SR	Heat pump	15-Sep-06
Austria	ESAROM	1	HeatPAC 104 SR	Pharmaceuticals	16-Apr-08
Austria	Agrana Gleisdorf, Heat Pump	1	HeatPAC 104 S	Fruit & vegetables	20-Apr-10
Austria	RAG - 13760025	1	HeatPAC 26	Non food industry	22-Dec-11
Austria	MACO	1	HeatPAC-104-S, R717	Other Manufacturing	04-Dec-12
Austria	Hermann Pfanner und Jonica Juice	1	HeatPAC 106 SV,	Beverage industry	28-Jun-13

Thank you for your attention