Heat to cool

Industrial Decarbonization

Presentation

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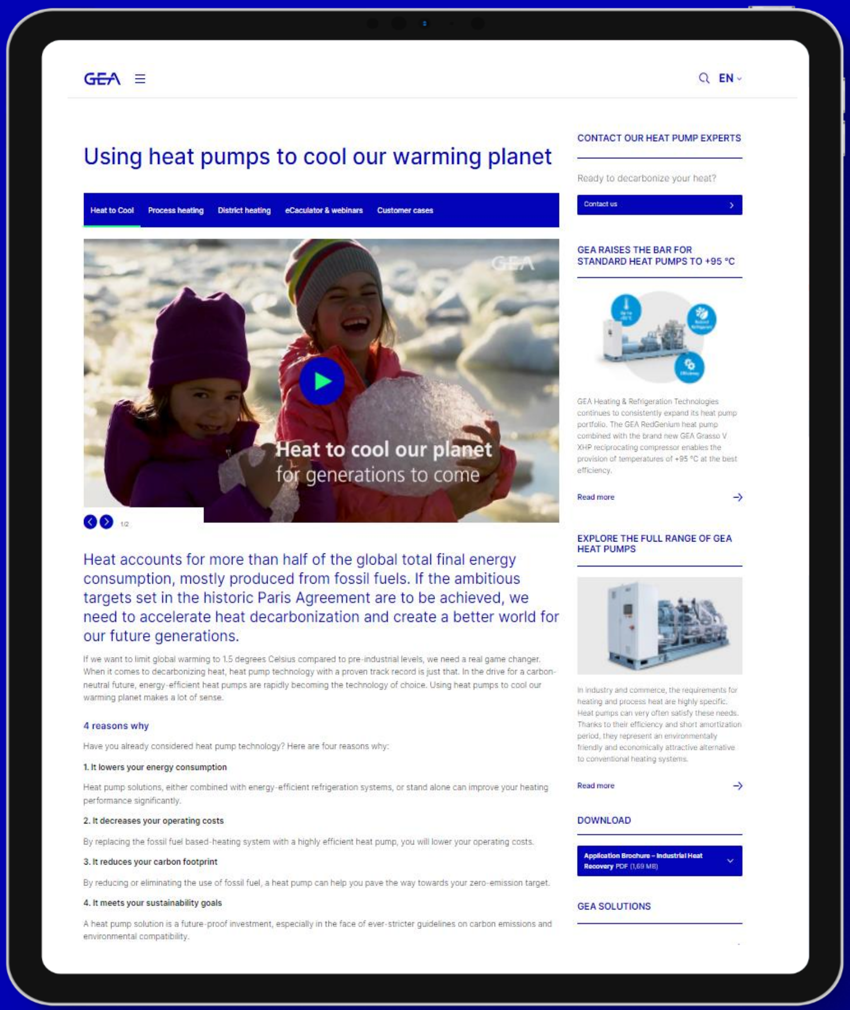
- Mechanical Engineer
- 32 years of experience
- United States

GEA.com/heat-to-cool



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CONTENT

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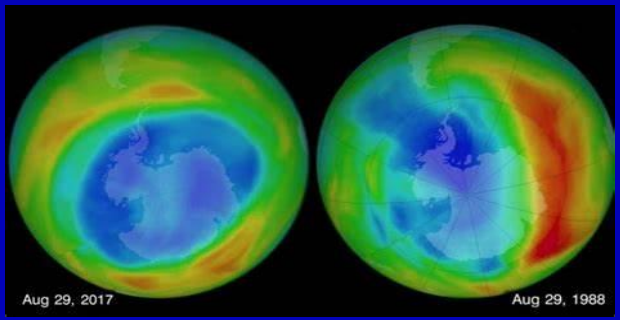
decarbonization

SUSTAINABILITY

Why decarbonize?

Ozone Layer

- In the last 30 years, human beings have made progress in stopping damage to the ozone layer.
- Recognition of the harmful effects of CFCs and other substances.
- It led to the signing of the Montreal Protocol in 1987: a landmark agreement for the phase-out of these substances.
- At the end of 2018, the UN confirmed in a scientific assessment that the ozone layer is recovering.



Climate Chage

- The Paris Agreement is an international treaty on climate change that was adopted on December 12, 2015 in Paris and entered into force on November 4, 2016.
- Their goal: to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels.
- To achieve this goal, countries aim to reduce greenhouse gas emissions as much as possible, acronym Green House Gases (GHG).

TIME magazine and Statista have determined the world's most sustainable companies for 2024.

GEA is one of the most sustainable companies in the world and is among the 33 best in the world and among the 3 best in Germany

Why decarbonize?

1. Commitment to climate change

2. Several countries require labels on the product that show the carbon footprint produced, with tax effects and restrictions.

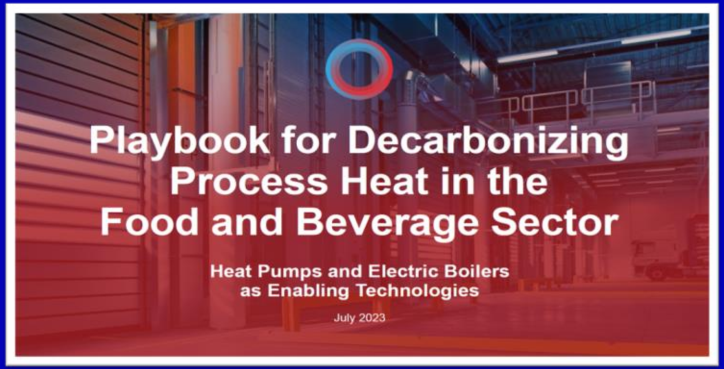
3. Several countries require the carbon footprint of the manufacturer, also with tax effects and restrictions. CARBON TAX

4. The consumer will have the option or purchase decision. The new generations are more aware.

How do we achieve this?

FIRST

Prevent emissions through RENEWABLE ENERGY technologies such as wind, solar, geothermal, biomass, hydrogen.



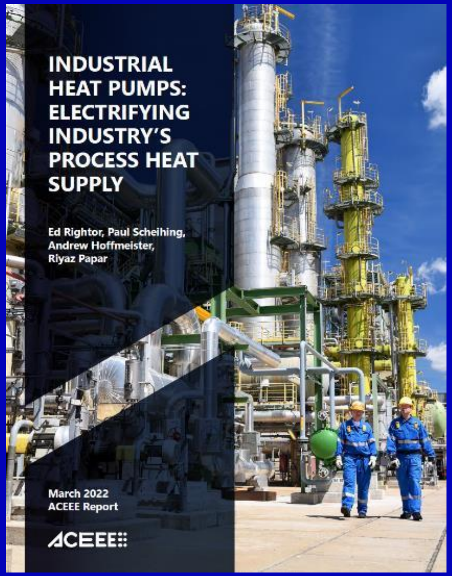
SECOND

Find heating process technologies other than fossil fuel combustion.

ELECTRIFY ALL HEATING PROCESSES.

Using electricity as the way to generate or produce heat.

Fuel change. Electricity for fuel.



The three scopes of Emissions

Scope 1

Direct Emissions:

All direct emissions, from the manufacturing process, your plant, what you produce in the product transformation.

Scope 2

Indirect emissions:

All forms of energy that you buy or use to be able to make the product transformation.

Scope 3

Associated emissions:

All forms of emissions produced in an associated manner. It can be your supply chain, the way your employees travel, your suppliers, etc.

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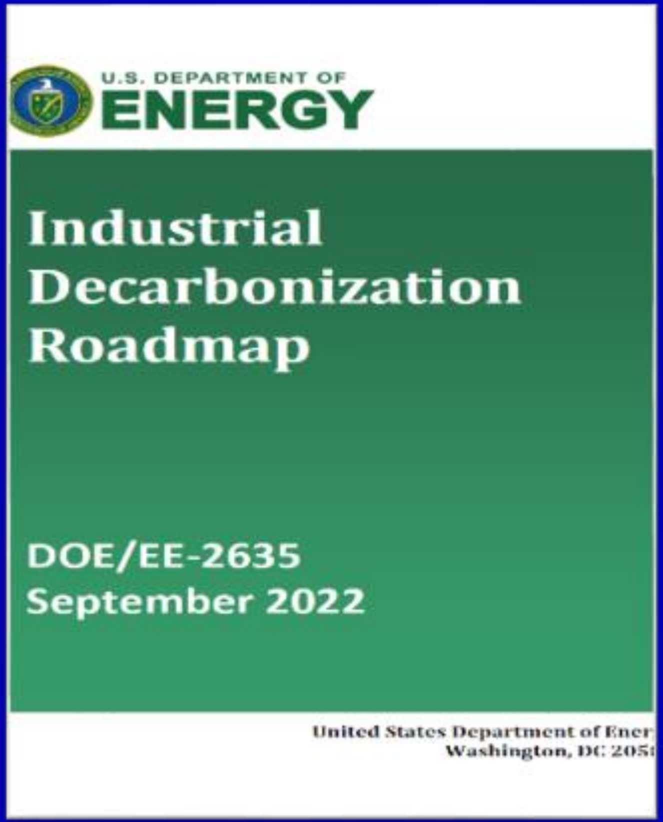
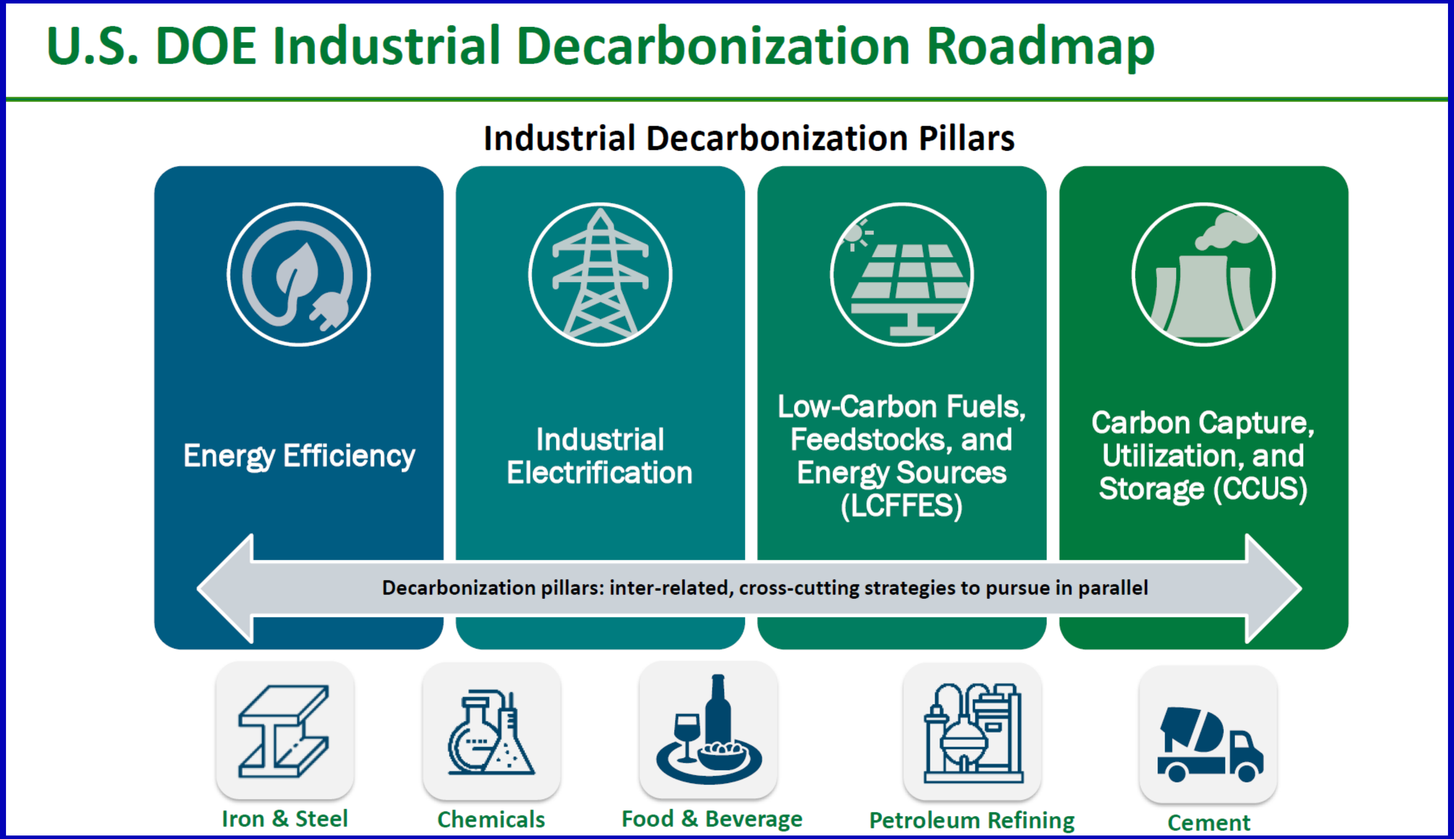
Route to industrial decarbonization

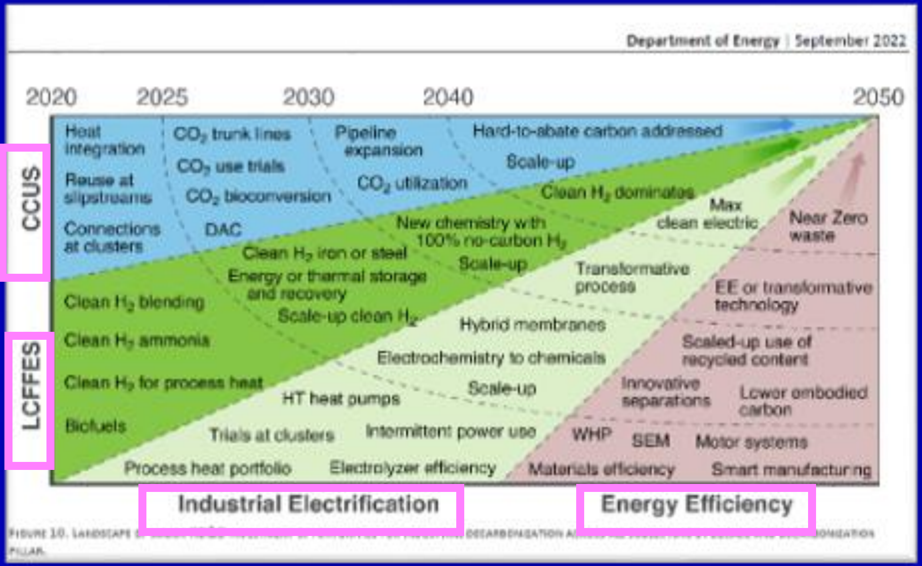
Department of Energy of the United States of America

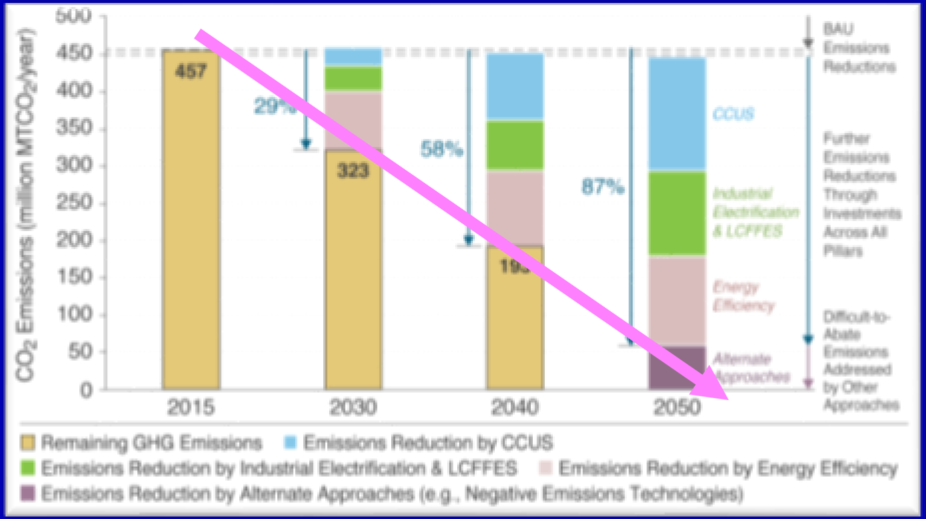




The 4 pillars of the road to Decarbonization

1. **Energy Efficiency:** improve your current process.
2. **Electrification:** combustion heating technologies, e.g. by means of electricity.
3. **LCFFES (Low Carbon Fuel FeedStocks & Energy Sources)** Switching to low or zero carbon fuel: switching from fossil fuel to biomass or hydrogen in the combustion process.
4. **CCUS (Carbon Capture, Utilization and Storage):** Technologies that capture emissions before or after combustion and then use or inject them back into the earth.





Gradually implement one by one and expand until a 100% reduction is achieved.

Heat pumps – Scopes of Emissions

SCOPE 1
Heat Pump
(Refrigerant Choice Option)

= 0 GWP Global Warming + 0 DAMAGE OZONE LAYER + 0 mol PFAs / TFAs Forever Chemicals

SCOPE 1
Heat Pump
(Heating Process)

= Efficiency Improvement + Process Electrification + 0 Fuel Consumption

SCOPE 2
Heat Pump
(Energy Consumption)

= Process Electrification + More Electricity Consumption + Renewable energy

To achieve Carbon Reduction, it is achieved with the Use of Natural Refrigerant, Heat Pump and Renewable Energies

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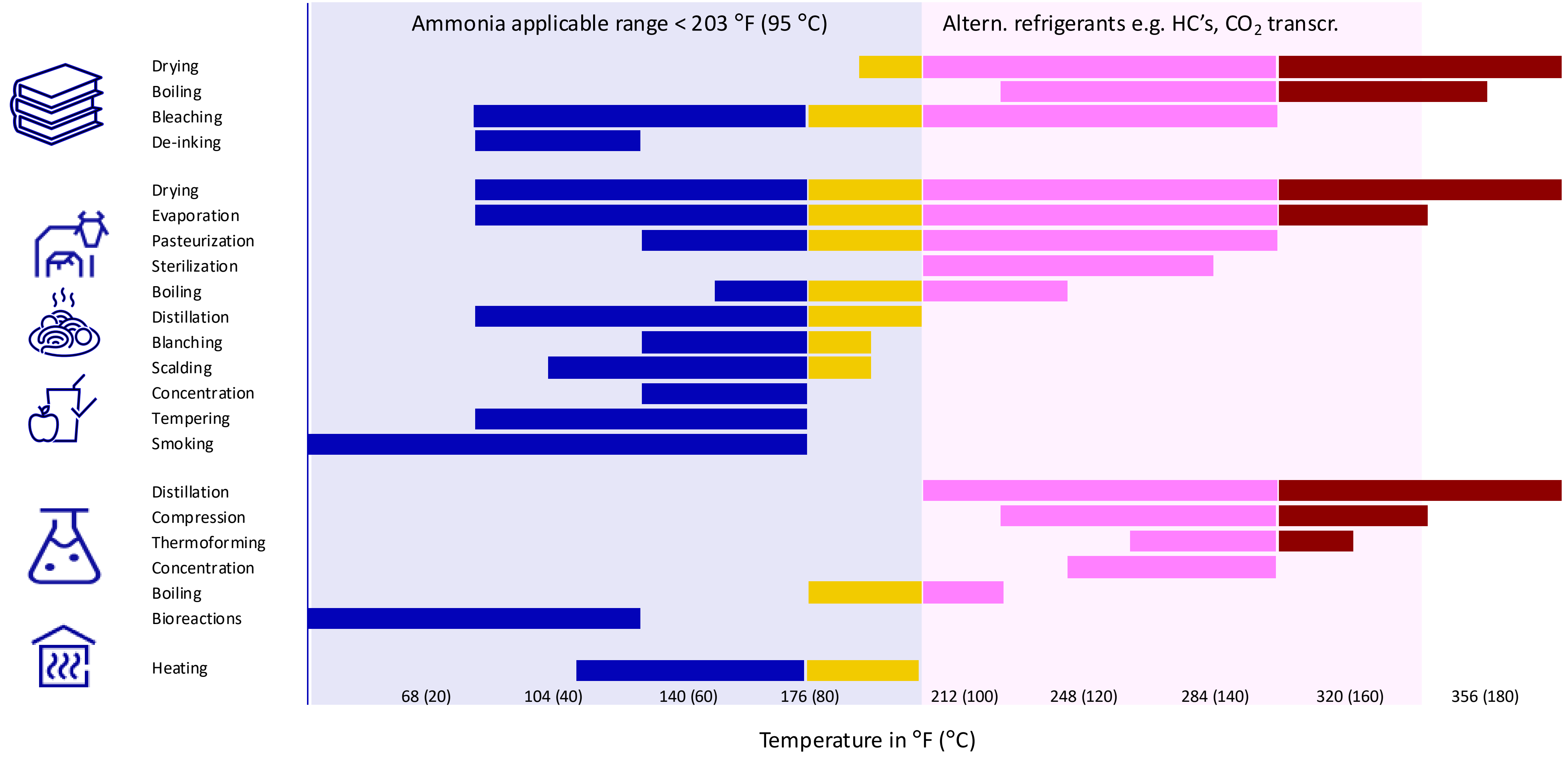
Heat pump applications & temperatures

Heating needs in the process industry and for space heating:



Relevance of refrigerants

Features & benefits of the natural ammonia:

GWP = 0

High availability

High Efficiency

ODP = 0
PFAS free

Low charges & costs

Safety

Example calculation with screw compressor [1]:

NH_3 is 40 % more efficient

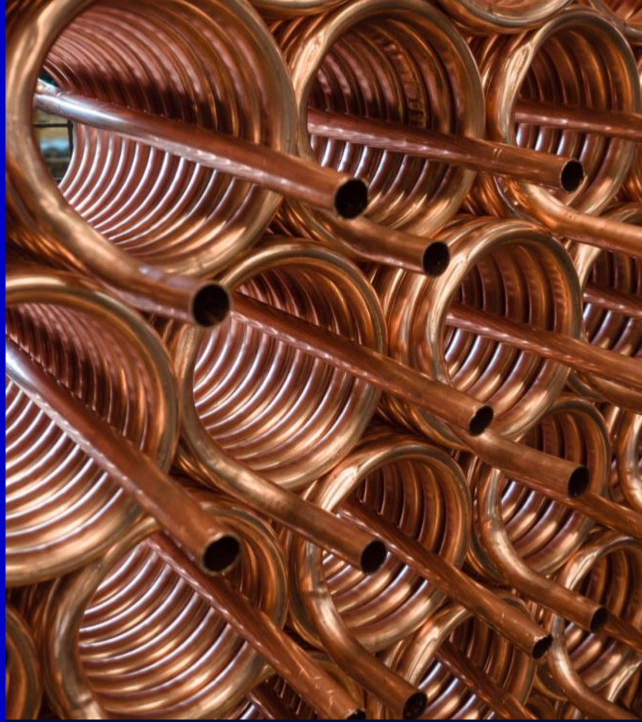
	COP in kW/kW	Heating Rating in MBH (kW)[1]	Vol. heating in kW/[m³/h]	GWP
R-717	**3,43**	**17,490** (5125)	**1,75**	**0**
R134a	2,71	[illegible]	0,88	1430
R152	2,95	[illegible]	1,03	124
R1234yf	2,37	8560 (2510)	0,86	4
R1234ze	2,59	7510 (2201)	0,75	7
R1336mzzZ	3,00	1770 (518)	0,18	7
R600a	3,03	5870 (1720)	0,59	3
R515B	2,39	6810 (1996)	0,68	293

NH_3 provides twice the capacity

1) Z-type (2,927 m³/h swept volume, at *+90/+77 °F (+32/+25 °C) heat source inlet/outlet, and +158/+194 °F (+70/+90 °C) heat carrier return/supply temperature.*

Thermal energy

SUSTAINABILITY



Understanding Thermal Energy Needs

Poultry Meat

+38 °C / 100.4°F

Dairy Beer Sodas Beverages

+2 °C / 35.6°F

Vegetables

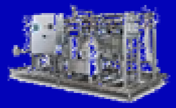
+20 °C / 68°F

HEATING

Defeathering/ Scalding /Plant Washing after slaughter and process.

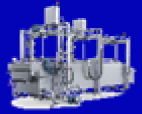
+52 °C /125.6°F

Pasteurization/ CIP/



+74 °C / 165.2°F

Bleaching / Washing



+80 °C / 176°F

COOLING

Cooling/Freezing

+2 °C /35.6°F

Cooling

+2 °C / 35.6°F

Freezing

-18 °C / -0.4°F

Final Product

+2 °C / 35.6°F

+2 °C / 35.6°F

-22 °C / -7.6°F

Same energy, but at different temperatures.

Heat: energy entering or being injected. Heat energy that goes out or is removed

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Available technology

LEVEL OF TECHNOLOGY AVAILABILITY

- Commercial Now Available for T < 100°C
- Prototype, pilot, demonstration
- Still in development. Laboratory.

TEMPERATURES: 20 °C / 68 °F, 40 / 104, 60 / 140, 80 / 176, 100 / 212, 120 / 248, 140 / 284, 160 / 320, 180 / 356, 200 / 392 (°C / °F)

SECTOR	PROCESS	TEMP RANGE (°C)	TEMP RANGE (°F)
Paper	Drying	90-240°C	194-464°F
	Boiling	110-180°C	230-356°F
	Bleaching	40-150°C	104-302°F
	De-inking	50-70°C	122-158°F
Food &Beverages	Drying	40-250°C	104-482°F
	Evaporation	40-170°C	104-338°F
	Pasteurization	60-150°C	140-302°F
	Sterilization	110-140°C	230-284°F
	Boiling	70-120°C	158-248°F
	Distillation	40-100°C	104-212°F
	Blanching	60-90°C	140-194°F
	Scalding	50-90°C	122-194°F
	Concentration	60-80°C	140-176°F
	Tempering	40-80°C	104-176°F
	Smoking	20-80°C	68-176°F
Chemical	Destillation	100-300°C	212-572°F
	Compression	110-170°C	230-338°F
	Thermoforming	130-160°C	266-320°F
	Concentration	120-140°C	248-284°F
	Boiling	80-110°C	176-230°F
	Bioreactions	20-60°C	68-140°F
Automotive	Resin Molding	70-130°C	158-266°F
Metal	Drying	60-200°C	140-392°F
	Pickling	20-100°C	68-212°F
	Degreasing	20-100°C	68-212°F
	Electroplating	30-90°C	86-194°F
	Phosphating	30-90°C	86-194°F
	Chromating	20-80°C	68-176°F
	Purging	40-70°C	104-158°F
Plastic	Injection Molding	90-300°C	194-572°F
	Pellets Drying	40-150°C	104-302°F
	Preheating	50-70°C	122-158°F
Mechanical Engineering	Surface Treatment	20-120°C	68-248°F
	Cleaning	40-90°C	104-194°F
Textiles	Coloring	40-160°C	104-320°F
	Drying	60-130°C	140-266°F
	Washing	40-110°C	104-230°F
	Bleaching	40-110°C	104-230°F
Wood	Glueing	120-180°C	248-356°F
	Pressing	120-170°C	248-338°F
	Drying	40-150°C	104-302°F
	Steaming	70-100°C	158212°F
	Cocking	80-90°C	176-194°F
	Staining	50-80°C	122-176°F
	Pickling	40-70°C	104-158°F
Several Sectors	Hot Water	20-110°C	68-230°F
	Preheating	20-100°C	68-230°F
	Washing /Cleaning	30-90°C	86-194°F
	Space Heating	20-80°C	68-176°F

Commercially available

Proven technology

AMMONIA R717 NH3

Up to 95°C

Prototype

LABORATORY DEVELOPMENT

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Combustion (boiler) vs. Heat pump (electricity)

Boilers

They produce or generate heat.

Are Oversized.

They deliver temperatures above process.

Efficiencies between 80% and 90% (COP 0.8 and 0.9).

Heat pumps

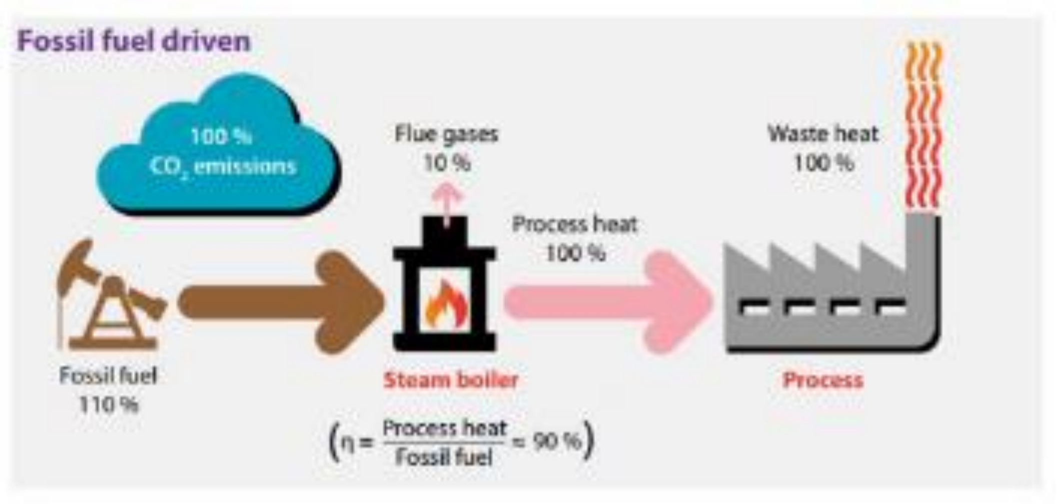
They do not produce heat, they move it.

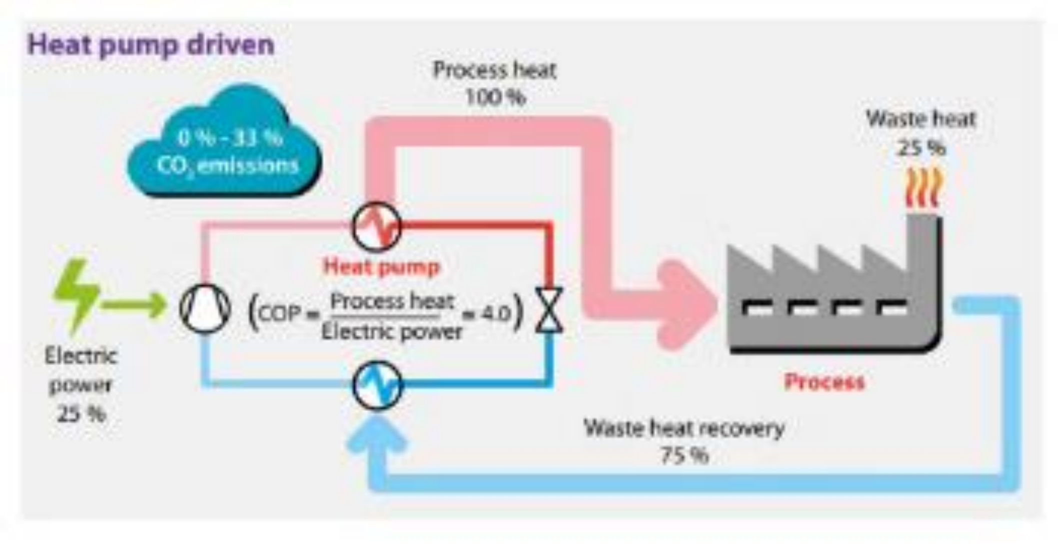
It is selected for the required load and there is no oversizing. They don't waste energy.

It is selected for the required temperature and not above it. Precision - Efficiency

Efficiencies between 300% and 1000% (COP 3.0 and 10.0)

They offer a double benefit: heating and cooling.





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Energy Cost Comparison / Spark Spread & Heat Pump Efficiency

Boiler Calculations					
Heat Capacity REQUIRED	kW	1500	5,115 MBH		
Boiler Efficiency	%	80%	COP = 0.8		
Running hours	h / y	5,400	18 hours/day * 6 days * 50 weeks / year		
Energy Consumed	BOILER	1,875	HEAT PUMP	500	kW
Naturals Gas Burned	kWh/y	10,125,000	Electricity Used kW / y	2,700,000	

HEAT PUMP COP 3.0

Assuming $800 / kW (800*1500)
Capital Cost of Heat Pump = $1,200,000
does not include other associated costs

$$Spark\ Gap = \frac{Electric\ Price\ \left(\frac{\$}{kW}\right)}{Gas\ Price\ \left(\frac{\$}{kW\ h\ eq}\right)}$$

$$Spark\ Gap = \frac{Electric\ Price\ \left(\frac{\$0.10}{kW}\right)}{Gas\ Price\ \frac{\$10}{MMBtu} * \left(\frac{1\ MMBtu}{293\ kW\ h}\right)} = 2.9$$

Cost / kw/h	Electricity kW/h	Natural Gas Price $/MMBtu	Natural Gas kW/h	Spark Gap (Ratio)	Boiler OPEX / y	Heat Pump OPEX / y	OPEX Diff / y	Return Of Investment (ROI) years
Lubbock, TX	$ 0.0481	$ 6.33	$0.0216	2.2	$218,700	$ 129,870	$ 88,830	14
Nevada	$ 0.1047	$ 10.84	$0.0370	2.8	$374,625	$ 282,690	$ 91,935	13
Trulock, CA	$ 0.1129	$ 13.60	$0.0464	2.4	$469,800	$ 304,830	$ 164,970	7
Fort Morgen, CO	$ 0.0432	$ 8.44	$0.0288	1.5	$291,600	$ 116,640	$ 174,960	7
Jerome, ID	$ 0.0543	$ 5.74	$0.0196	2.8	$198,450	$ 146,610	$ 51,840	23

*ROI does not include other savings that may help reduce ROI, like water savings and others

	MW/ h	MW /h
Lubbock, TX	$ 48.10	$ 21.60
Nevada	$ 104.70	$ 37.00
Trulock, CA	$ 112.90	$ 46.40
Fort Morgen, CO	$ 43.20	$ 28.80
Jerome, ID	$ 54.30	$ 19.60

$$Savings\ on\ Energy\ Costs = \frac{Gas\ Price - \left(\frac{kw\ Price}{IHP\ COP}\right)}{Gas\ Price}$$

Savings on Energy Costs	
≈	26%
≈	6%
≈	19%
≈	50%
≈	8%

Boiler Calculations					
Heat Capacity REQUIRED	kW	1500	5,115 MBH		
Boiler Efficiency	%	80%	COP = 0.8		
Running hours	h / y	5,400	18 hours/day * 6 days * 50 weeks / year		
Energy Consumed	BOILER	1,875	HEAT PUMP	375	kW
Naturals Gas Burned	kWh/y	10,125,000	Electricity Used kW / y	2,025,000	

HEAT PUMP COP 4.0

Assuming $800 / kW (800*1500)
Capital Cost of Heat Pump = $1,200,000
does not include other associated costs

$$Spark\ Gap = \frac{Electric\ Price\ \left(\frac{\$}{kW}\right)}{Gas\ Price\ \left(\frac{\$}{kW\ h\ eq}\right)}$$

$$Spark\ Gap = \frac{Electric\ Price\ \left(\frac{\$0.10}{kW}\right)}{Gas\ Price\ \frac{\$10}{MMBtu} * \left(\frac{1\ MMBtu}{293\ kW\ h}\right)} = 2.9$$

Cost / kw/h	Electricity kW/h	Natural Gas Price $/MMBtu	Natural Gas kW/h	Spark Gap (Ratio)	Boiler OPEX / y	Heat Pump OPEX / y	OPEX Diff / y	Return Of Investment (ROI) years
Lubbock, TX	$ 0.0481	$ 6.33	$0.0216	2.2	$218,700	$ 97,403	$ 121,298	10
Nevada	$ 0.1047	$ 10.84	$0.0370	2.8	$374,625	$ 212,018	$ 162,608	7
Trulock, CA	$ 0.1129	$ 13.60	$0.0464	2.4	$469,800	$ 228,623	$ 241,178	5
Fort Morgen, CO	$ 0.0432	$ 8.44	$0.0288	1.5	$291,600	$ 87,480	$ 204,120	6
Jerome, ID	$ 0.0543	$ 5.74	$0.0196	2.8	$198,450	$ 109,958	$ 88,493	14

*ROI does not include other savings that may help reduce ROI, like water savings and others

	MW/ h	MW /h
Lubbock, TX	$ 48.10	$ 21.60
Nevada	$ 104.70	$ 37.00
Trulock, CA	$ 112.90	$ 46.40
Fort Morgen, CO	$ 43.20	$ 28.80
Jerome, ID	$ 54.30	$ 19.60

$$Savings\ on\ Energy\ Costs = \frac{Gas\ Price - \left(\frac{kw\ Price}{IHP\ COP}\right)}{Gas\ Price}$$

Savings on Energy Costs	
≈	44%
≈	29%
≈	39%
≈	63%
≈	31%

Spark Gap is the Electrical/$Kw Fuel Cost Ratio $kw

Scoping Test (Proof of Savings Form)

IHP COP	3.0
Gas Boiler Efficiency	80%
Efficiency Ratio (IHP COP/ Boiler eff)	3.75

If the smallest Spark Gap, < 3.75, saves energy, gas is NOT convenient, electricity is.
If the Spark Gap equals, = 3.75, costs associated with the expense of gas or electricity would be even.
If the Spark Gap is greater, > 3.75, more is spent on electricity than on using gas, i.e., Gas is convenient.

The heat pump is more efficient than the boiler.

Increasing the COP performance coefficient:
- **OPEX improvement of the heat pump.**
- **Increases energy savings.**
- **Reduces ROI time.**

PISTON & SCREW EFFICIENCY

Required Capacity 9 MW / 180°F

PISTON

	WINTER	SUMMER
Heat Sink		
Process Fluid	Water	Water
Required Heating Capacity (KW)	5 X 1800	5 X 1800
Inlet Temperature (°F)	40	40
Outlet Temperature (°F)	180	180
Heat Source- Cascade Condenser		
General Data		
Chiller Model	RedGenium 950	RedGenium 950
Capacity per System (KW)	5 X 1800	5 X 1800
No. of Systems	5	5
Type of Compressor	Piston Model V950 XHP	Piston Model V950 XHP
Compressor Motor BHP	432	432
Compressor Motor HP	500	500
Efficiency Summary		
COP - Coefficient of Performance (line)	5.13	5.78
COP - Coefficient of Performance (shaft)	5.59	6.29
Total electrical consumption (line), kW	351	311

(Sell Price for 5 Units)$3,141,550 USD

Only Full Load Calculation		PISTON	SCREW
Running Hours per Year	5000		
TCO Period in Years	1		
Energy Costs per kW	$0.12		
Capacity Heating kW	9000		
COP		5.13	4.27
Total unit Energy Consumption kWh		1755	2108
Total Energy Cost over Period		$1,053,000	$1,264,800
Savings		$211,800	
PAYBACK years		3	

SCREW

	WINTER	SUMMER
Heat Sink		
Process Fluid	Water	Water
Required Heating Capacity (KW)	4 X 2250	4 X 2250
Inlet Temperature (°F)	40	40
Outlet Temperature (°F)	180	180
Heat Source- Cascade Condenser		
General Data		
Chiller Model	RedAstrum RN	RedAstrum RN
Capacity per System (KW)	4 X 2250	4 X 2250
No. of Systems	4	4
Type of Compressor	Screw Model 230 GL	Screw Model 230 GL
Compressor Motor BHP	646.2	646.2
Compressor Motor HP	800	800
Efficiency Summary		
COP - Coefficient of Performance (line)	4.27	4.64
COP - Coefficient of Performance (shaft)	4.67	5.08
Total electrical consumption (line), kW	527	485

(Sell Price for 4 Units)$ 2,508,533 USD

Price Difference $ 633,017 USD BUT………. Payback on Piston becomes after 3 years resulting in more savings through whole lifecycle

PISTON HEAT PUMP EFFICIENCY & SCREW HEAT PUMP EFFICIENCY

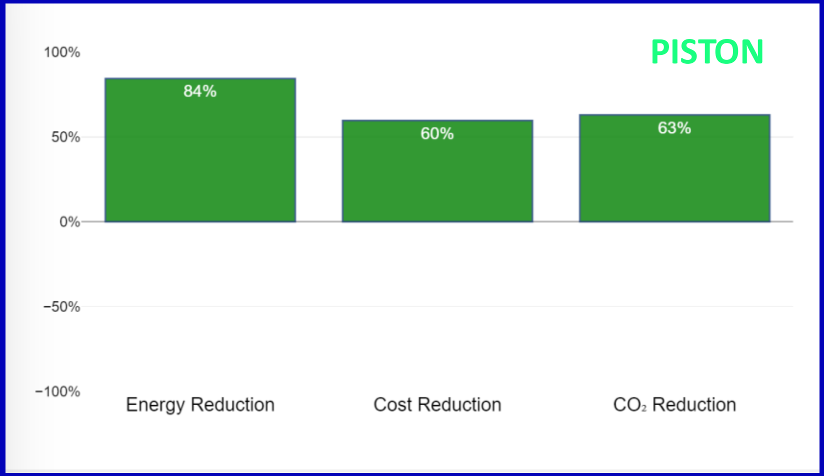
HEAT PUMP COP   COP 5.13

PISTON

(Sell Price for 5 Units)$3,141,550 USD

Boiler Calculations							
Heat Capacity REQUIRED	**kW**	**9000**	30,708 MMBH				
Boiler Efficiency	%	80%	COP = 0.8				
Running hours	h / y	5,000					
Energy Consumed	BOILER	11,250	**HEAT PUMP**	**1754**	kW		
Naturals Gas Burned	kWh / year	**56,250,000**	Electricity Used kW / y	**8,771,930**	Energy Savings	47,478,070	Kw/y

Cost / kw/h	Electricity kW/h	Natural Gas Price $/MMBtu	Natural Gas kW/h	Spark Gap (Ratio)	Boiler OPEX / y	Heat Pump OPEX / y	OPEX Diff / y	Return Of Investment (ROI) years
	$ 0.1200	$ 13.60	$ 0.0464	2.6	$ 2,610,000	$ 1,052,632	$ 1,557,368	2



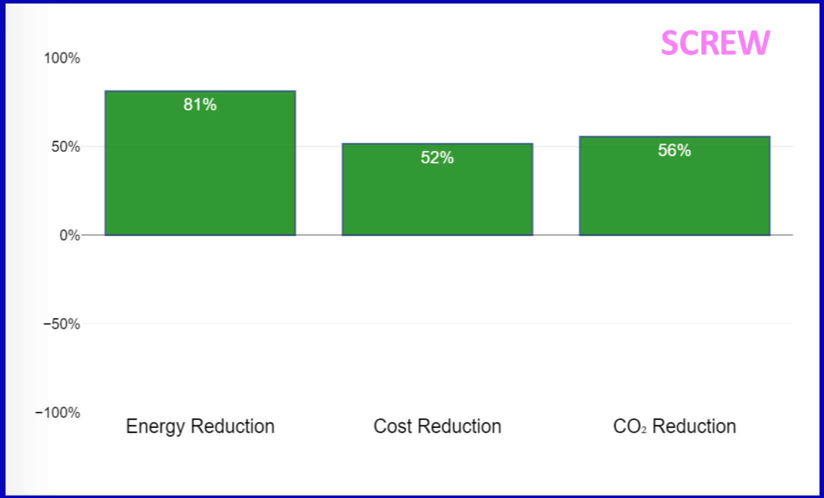
HEAT PUMP COP   COP 4.27

SCREW

(Sell Price for 4 Units)$ 2,508,533 USD

Boiler Calculations							
Heat Capacity REQUIRED	**kW**	**9000**	30,708 MBH				
Boiler Efficiency	%	80%	COP = 0.8				
Running hours	h / y	5,000					
Energy Consumed	BOILER	11,250	**HEAT PUMP**	**2108**	kW		
Naturals Gas Burned	kWh / year	**56,250,000**	Electricity Used kW / y	**10,538,642**	Energy Savings	45,711,358	Kw/y

Cost / kw/h	Electricity kW/h	Natural Gas Price $/MMBtu	Natural Gas kW/h	Spark Gap (Ratio)	Boiler OPEX / y	Heat Pump OPEX / y	OPEX Diff / y	Return Of Investment (ROI) years
	$ 0.1200	$ 13.60	$ 0.0464	2.6	$ 2,610,000	$ 1,264,637	$ 1,345,363	2



Price Difference $ 633,017 USD but ………………. Energy Savings and CO2 Abetment will be diminished due to low COP

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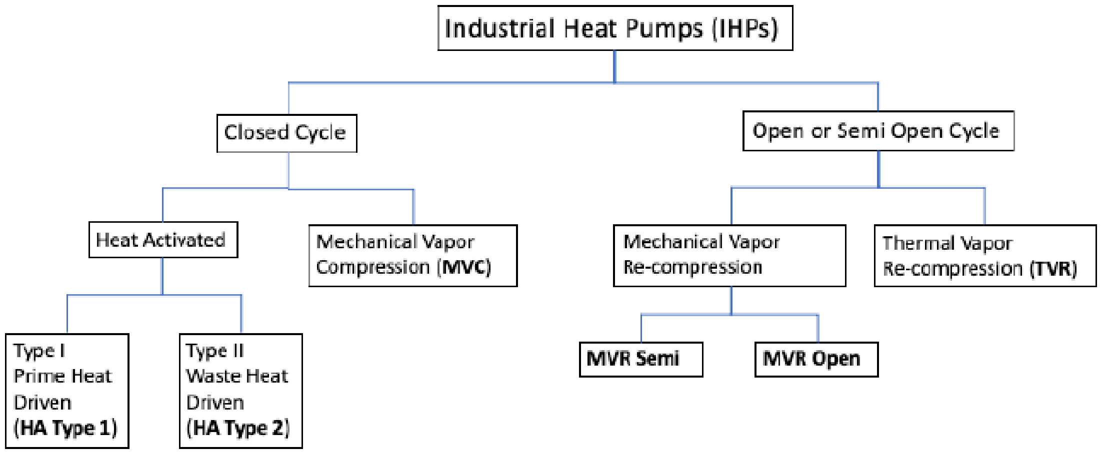
Technologies
Heat Pumps

Heat pump technologies

CLOSED LOOP

HTHP
High-temperature heat pump

- Refrigerant Compression

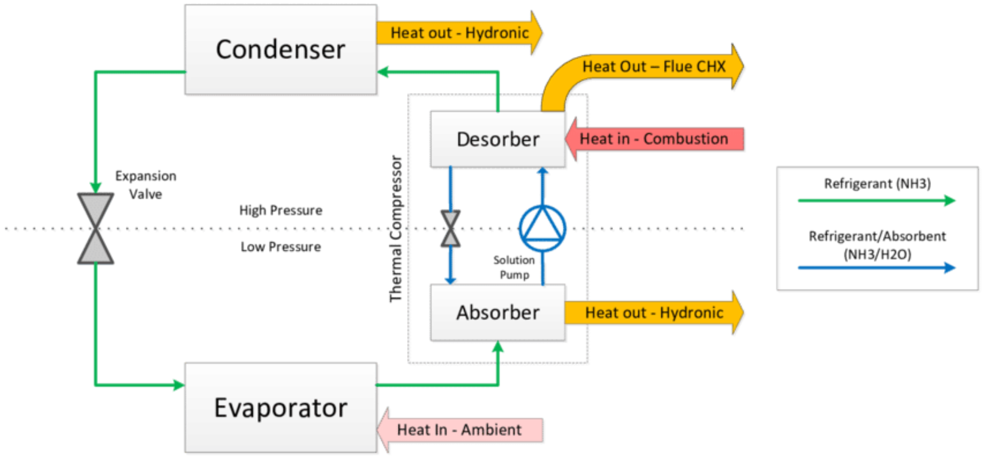


OPEN CYCLE

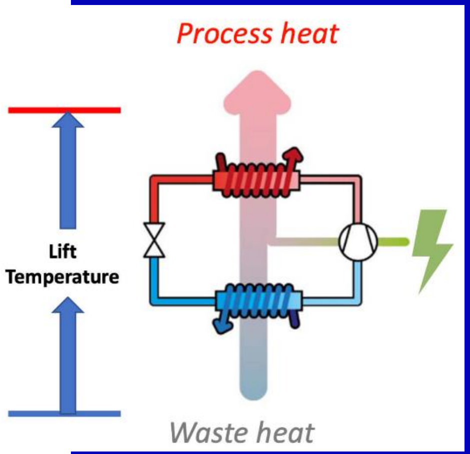
SGHP

Steam-Generating Heat Pump
Vapor Recompression

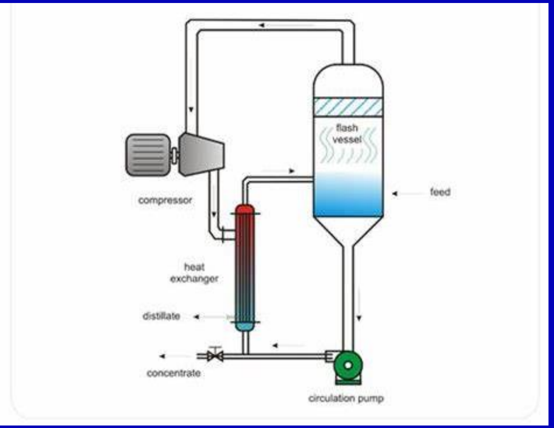
Absorption cycles



Refrigerant compression cycles



Steam Recompression Cycles



Application – Principle of Operation

Compression Cycle

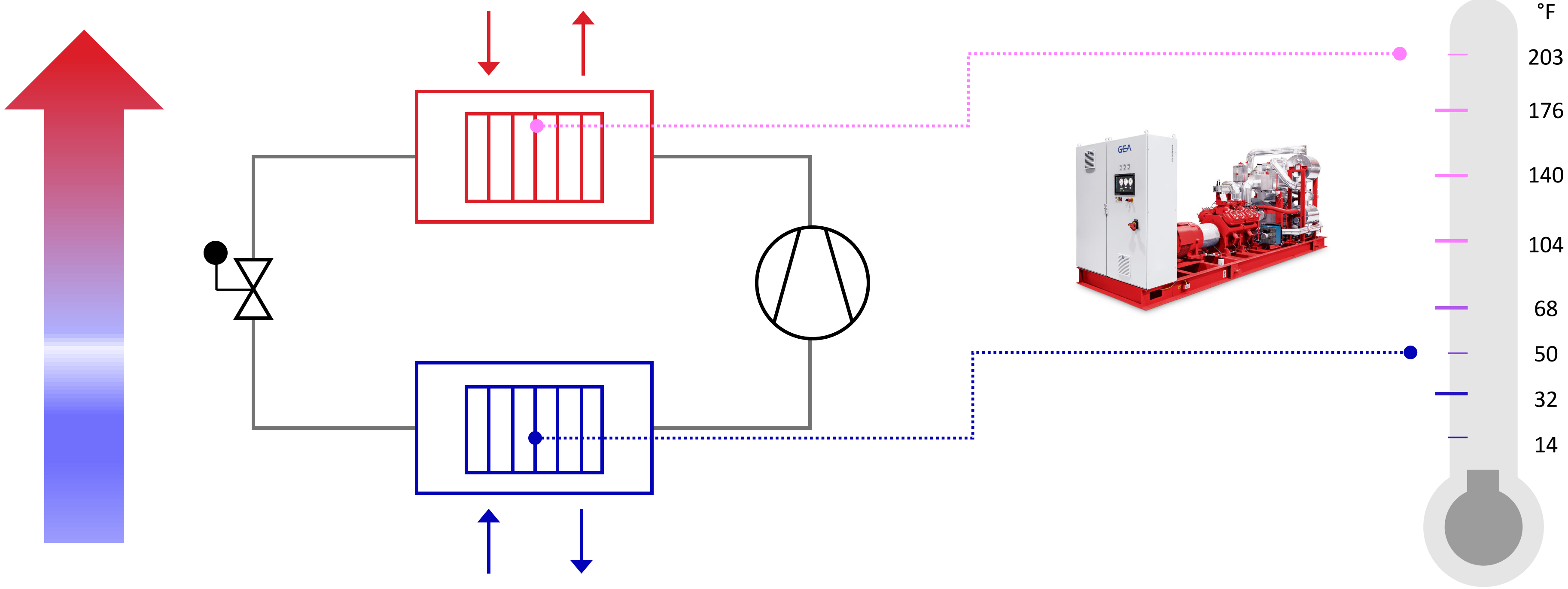
Process heat for various industries

Food, dairy and beverage production

Heat sink

District/installation heating, hot water

By means of compression, rising to higher pressure = higher condensing = higher temperature



Process Heat/Waste Water

Cooling circuits

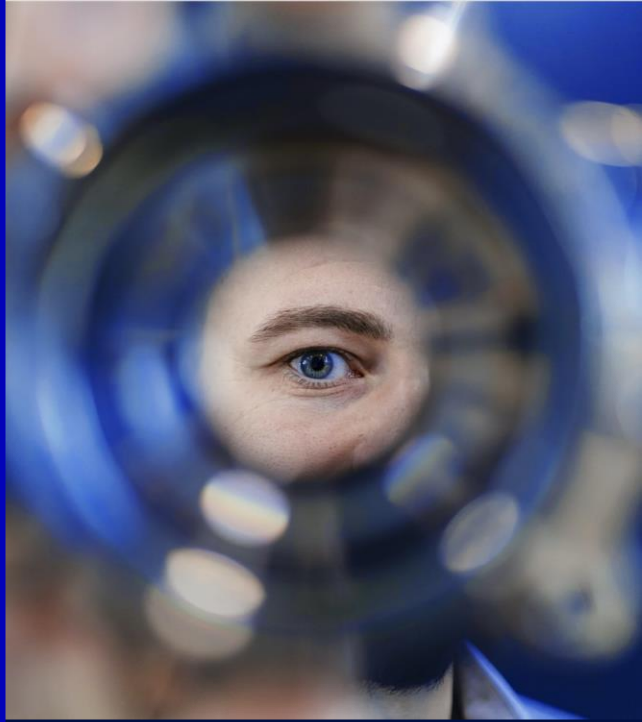
Heat source

(liquid)

Environmental sources (sea, river, lakes, ...)

HEAT PUMPS gea

SUSTAINABILITY



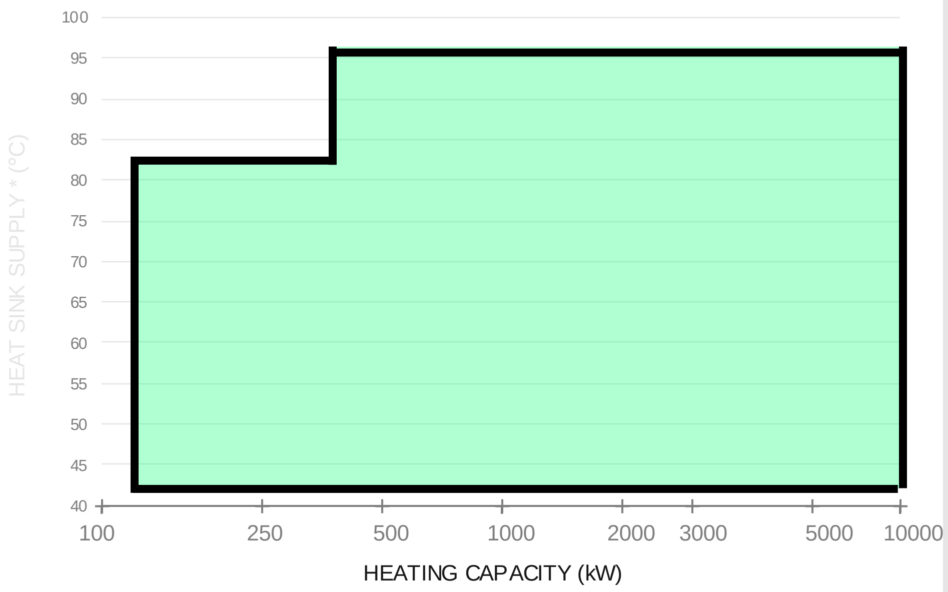
GEA

Ammonia Heat Pump Example

GEA RedGenium

GEA Portfolio in Heat Pumps – Capacity

Temperature Application Diagram



The highlighted area shows the range of supply temperatures for heating demand and heat capacity at the ambient heat source level.

RedGenium

Piston Heat Pump

11 types

Up to +95 °C / 203°F

- 150 – 3,500 kW
- 511 – 11,945 MBH

Approach:

Higher supply temperatures

Best-in-class efficiency

Lower power consumption

RedAstrum

Screw Type Heat Pump

7 types

Up to +85 °C / 185°F

- 500 – 3,000 Kw
- 1706 – 10,238 MBH

Approach:

Low installation footprint

High differential pressures

Focused for high differential temperature between heat source and heat reservoir

Blu-Red Fusion

Chiller + Heat Pump

Multiple types

Up +95 °C /203°F

- 500 – 3,500 kW
- 1706 – 11,945 MBH

Approach:

Combined cooling and heating

Maximum efficiency

Flexibility
Simultaneous or variable cooling and heating possible.

Custom

Custom Heat Pumps
All compressors

Up to +95 °C / 203°F

- 250 – 10,000 Kw
- 853 – 34,129 MBH

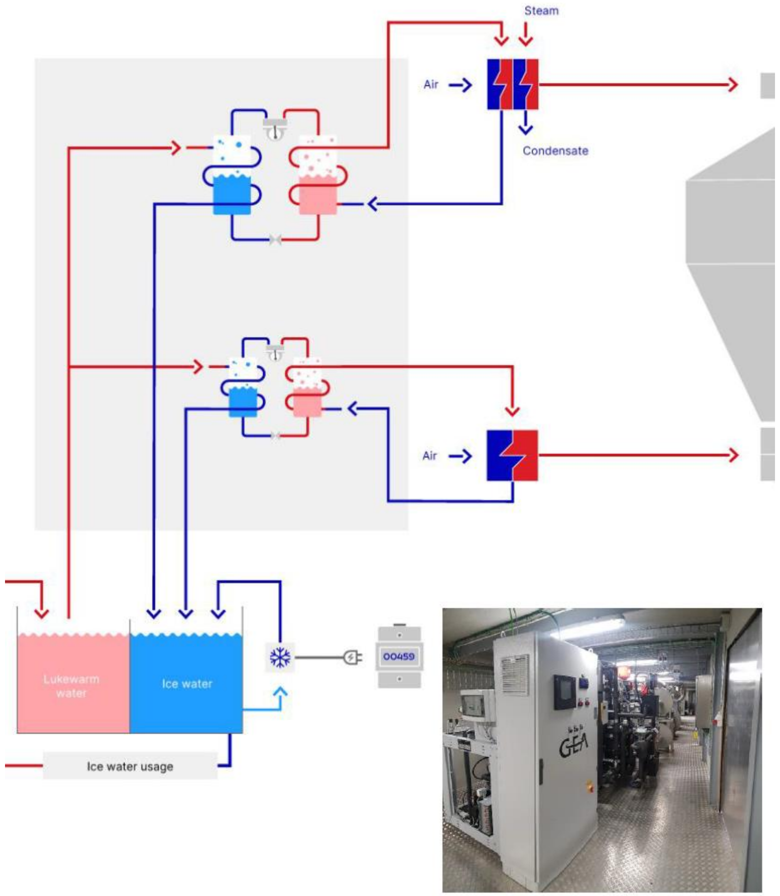
Approach:

High Heat Capacity

Many flexible design and configuration options

ADD COOL

Spray drying



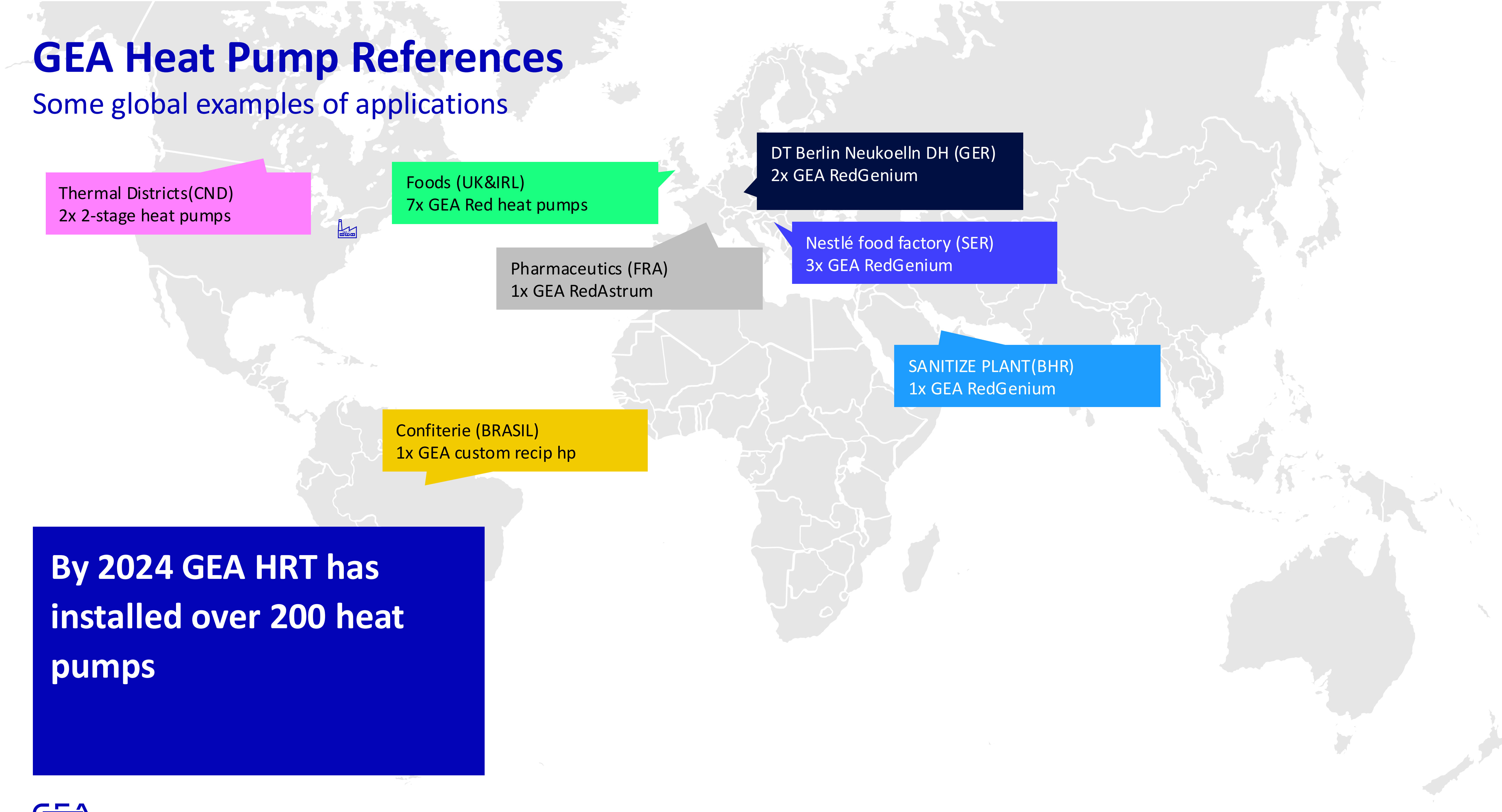
- Spray drying is an industry-standard method for making high-quality, stable powder products.
- The production of the hot air used by the atomization tower usually uses energy generated by fossil fuels.
- To make spray drying more sustainable, GEA integrates heat pumps

ADDCOOL GEA uses CO2 Refrigerant heat pumps to preheat air up to temperatures of 120°C

- At the same time, 2°C cold water is generated that can be supplied to the existing cold water network to reduce energy consumption
- Drying Operation and Product Quality Are Not Affected

GEA Heat Pump References

Some global examples of applications



By 2024 GEA HRT has installed over 200 heat pumps

GEA Heat Pumps References

North America

1x RedGenium 950 (K)
5,800 MBH / 1.7 MW

1x RedGenium 550 (K)
3,412 MBH / 1 MW

1x RedGenium 950 (K)
7,000 MBH / 2.05 MW

2x RedGenium 950 (W)
14,672 MBH / 4.3 MW total

2x 2-stage heat pumps
13,650 MBH / 4 MW total

2x RedGenium 950 (K)
14,332 MBH / 4.2 MW total

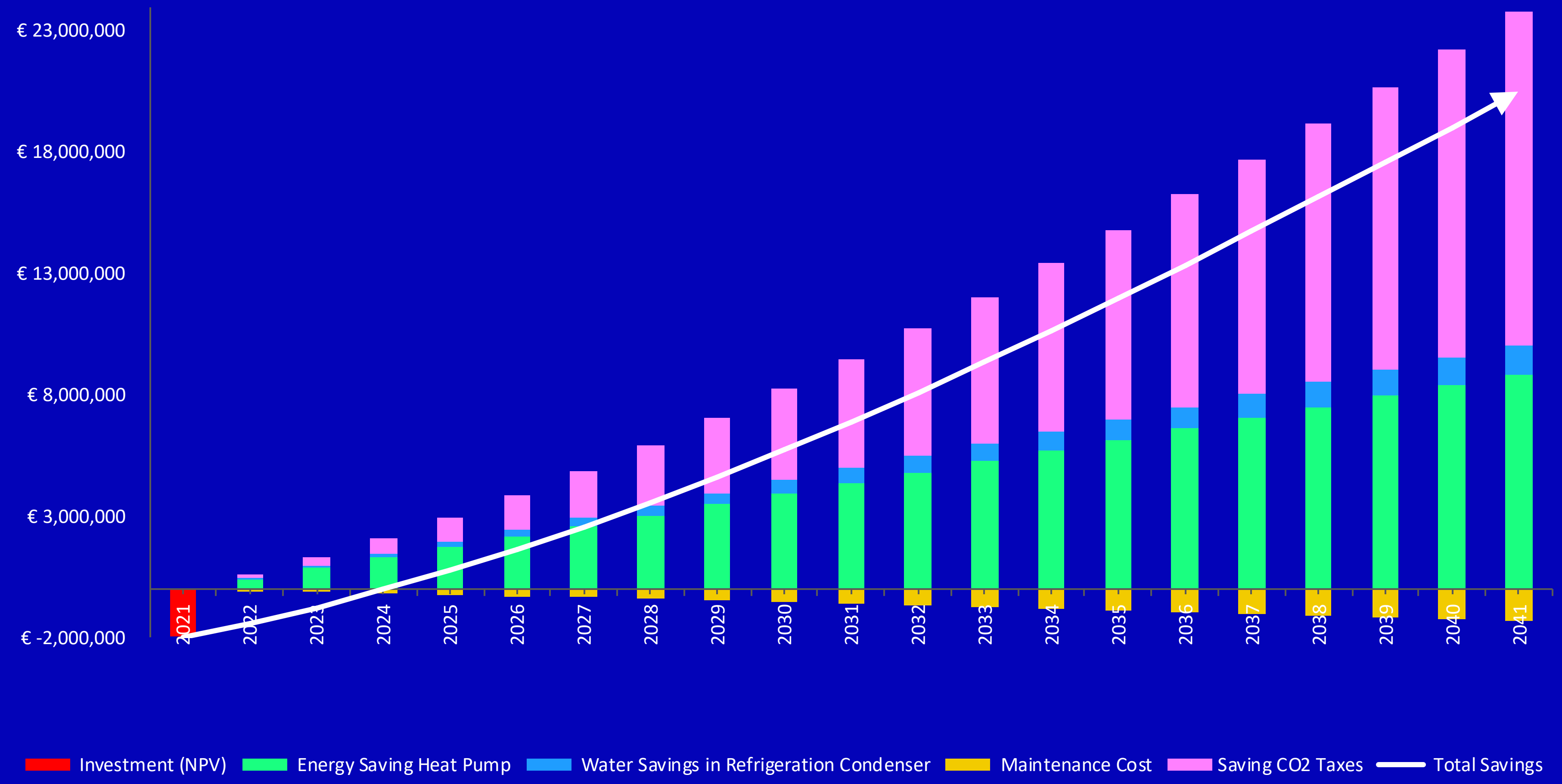
Applications

- **Dairy**
- **District Thermals**
- **Brewery**
- **Food**

The map shows the location of current heat pump projects for GEA North America.
The heat pumps may be at different stages (in operation, commissioning, in production).

Total Cost Owner ship - TCO

INNOCENT - The World's First Cimate Neutral Juice Factory



SEnS Sustainable Engineering Solutions

innocent

Total savings
$ 20.500.386

CO_2 emissions avoided 103,158 tons (green electricity)

Fuel price $ 0.207 /Nm3

Electricity price $0.052 /kWh

CO_2 emits. ($/ton/y)$ 30

Annual energy cost increases acc. Polynomial

Annual water cost increases 0%

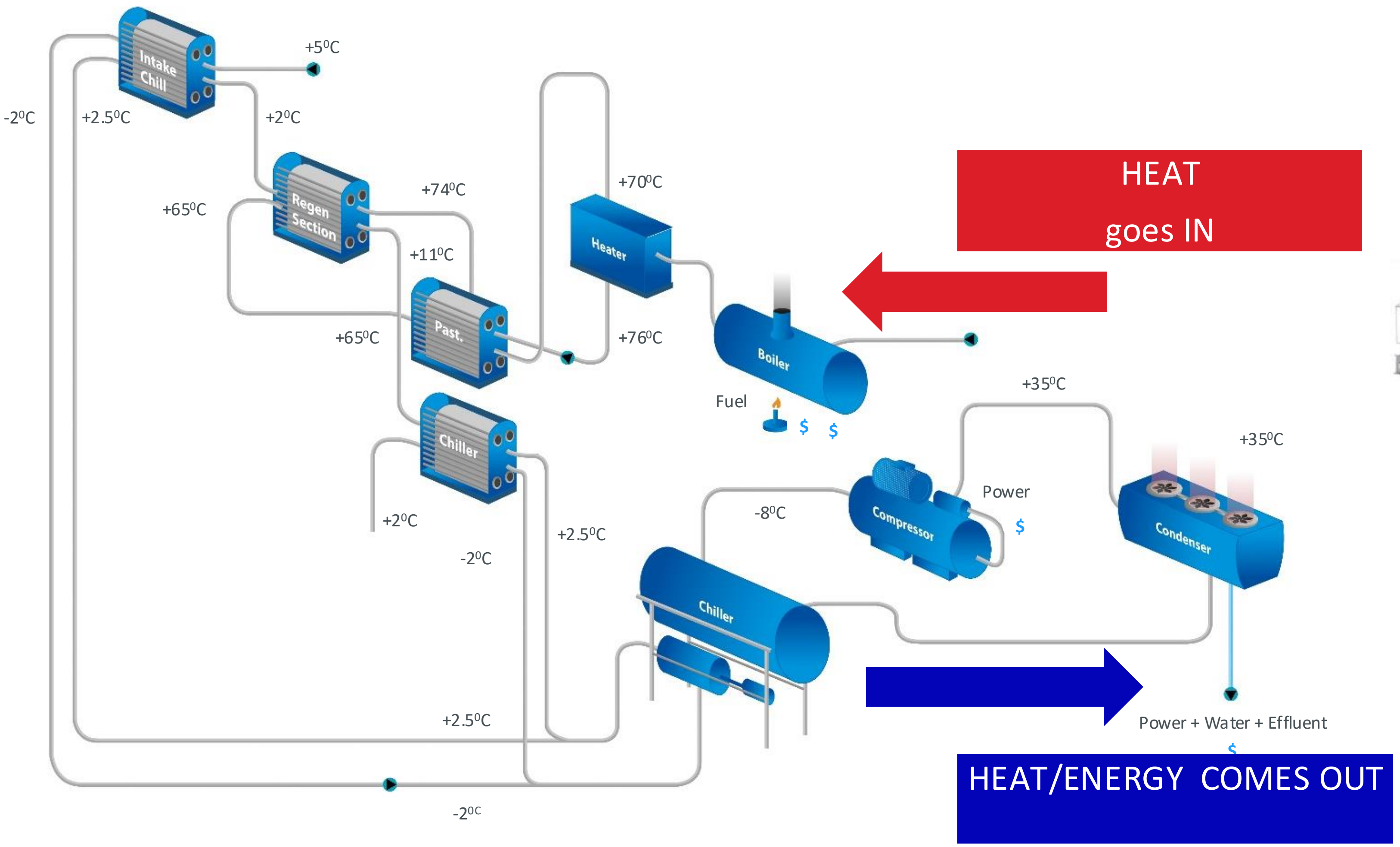
Annual maintenance cost increases 2%

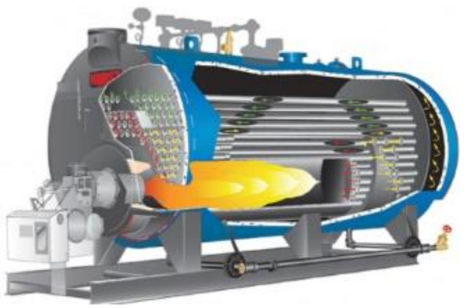
Annual CO_2 tax increases acc. Polynomial

Application examples

Example in dairy products

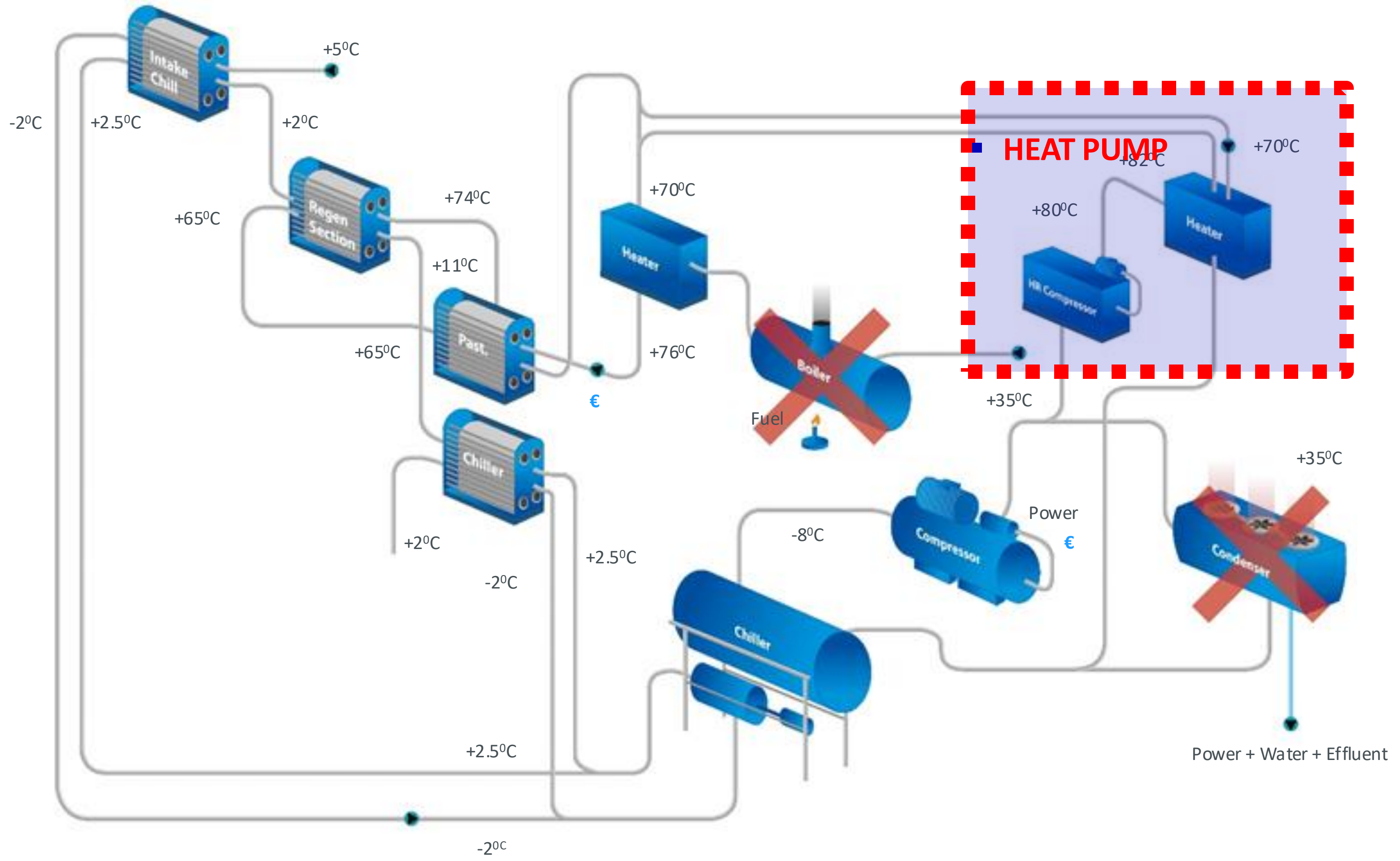
Cooling and heating





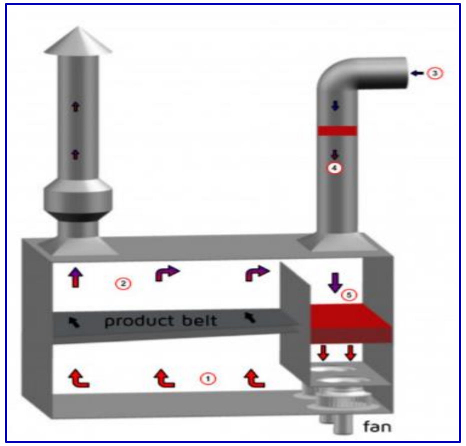
Example in dairy products

Cooling and heating

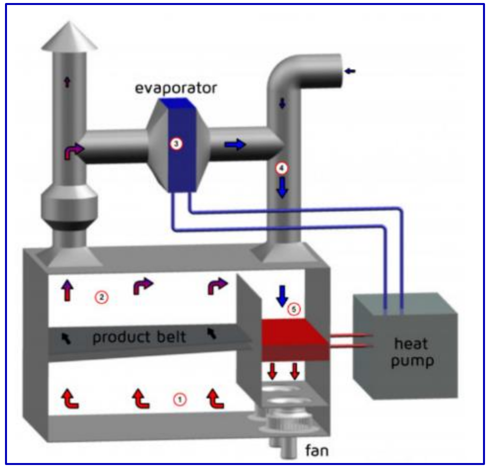


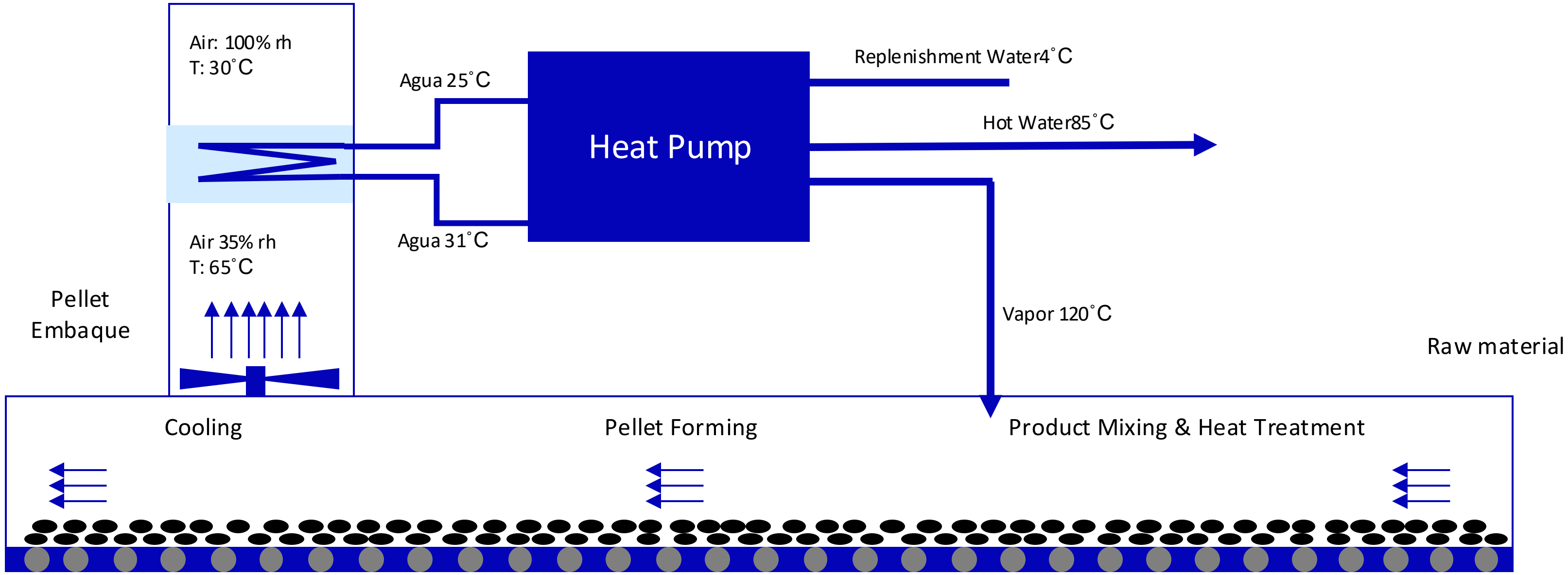
Example in drying

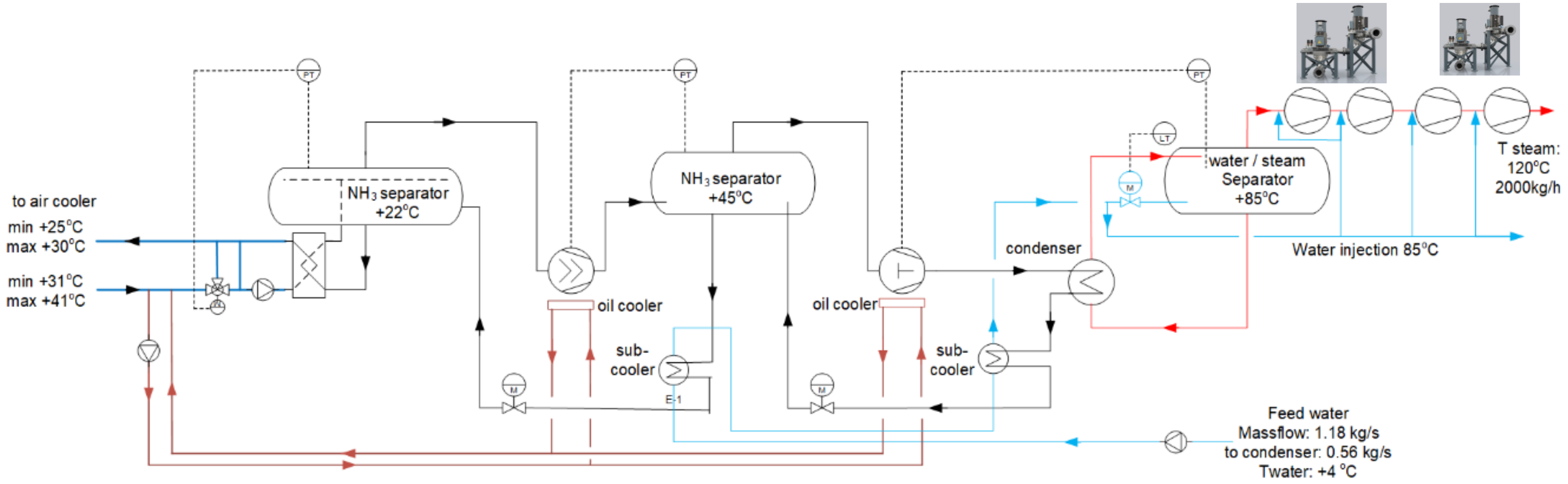
CONVENTIONAL DRYING



DRYING VIA HEAT PUMP







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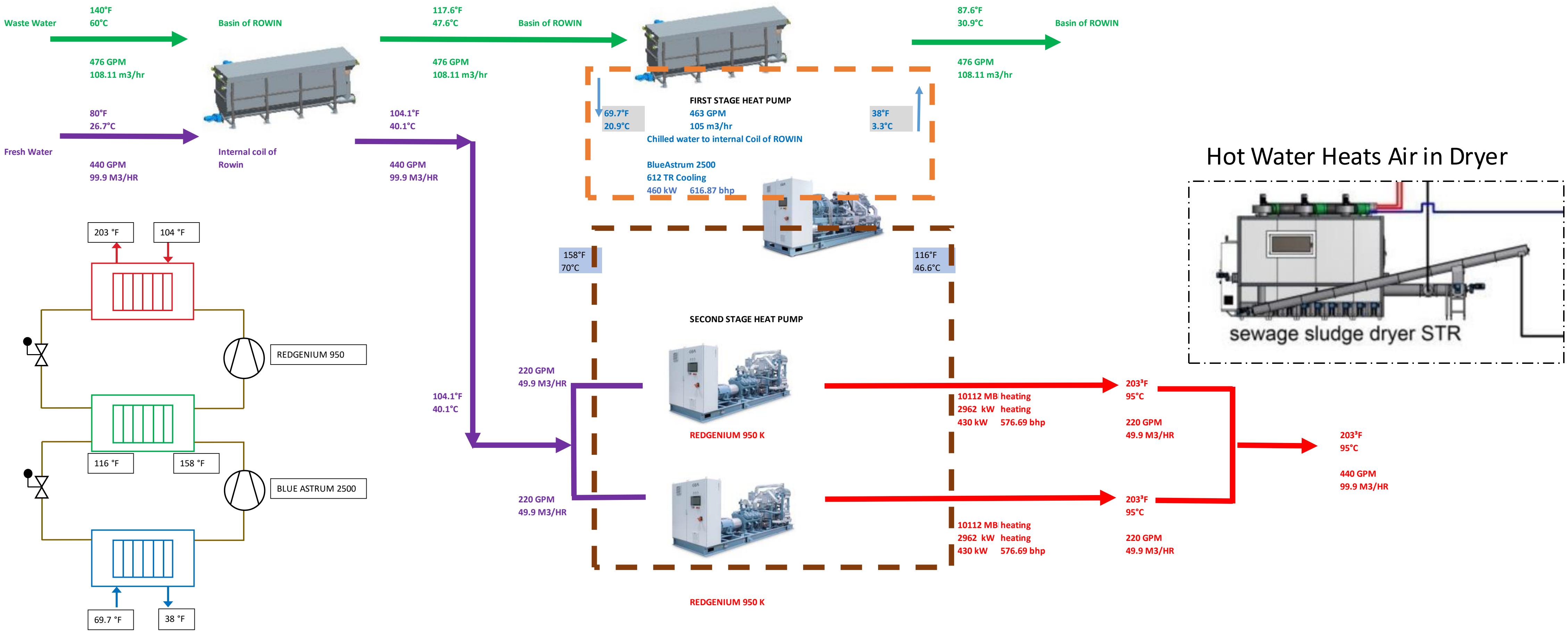
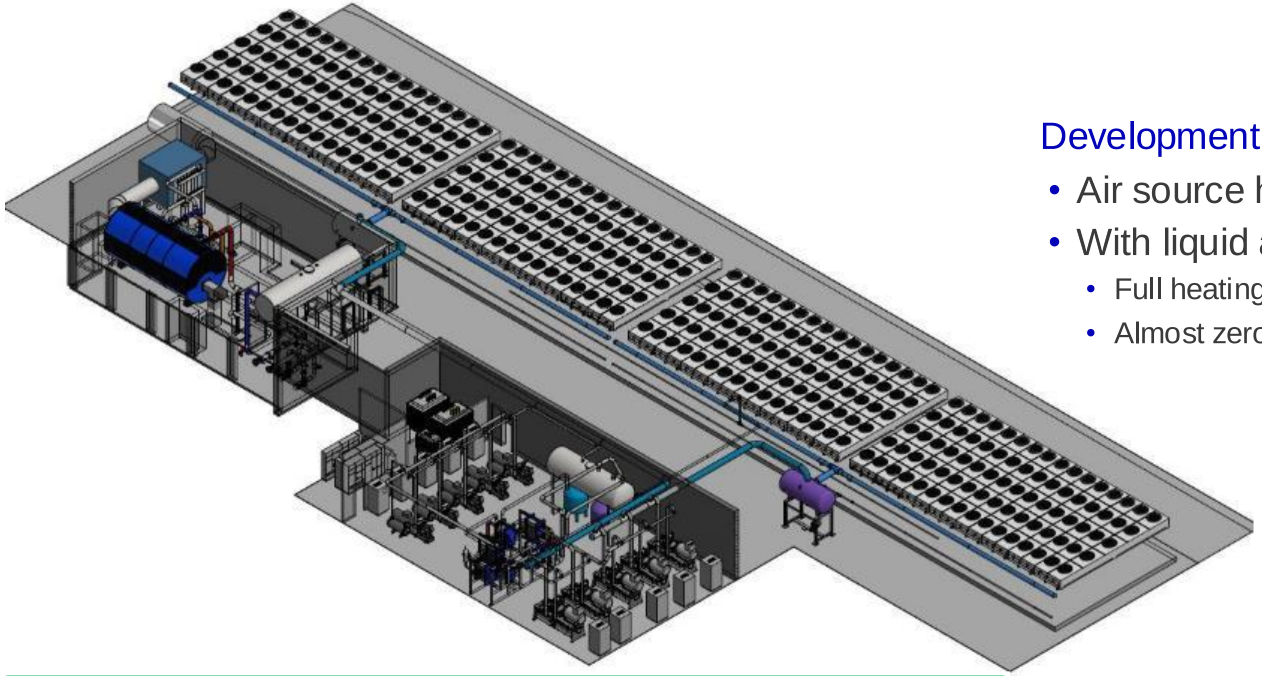
Example Wastewater / Water Treatment / Sewage Water

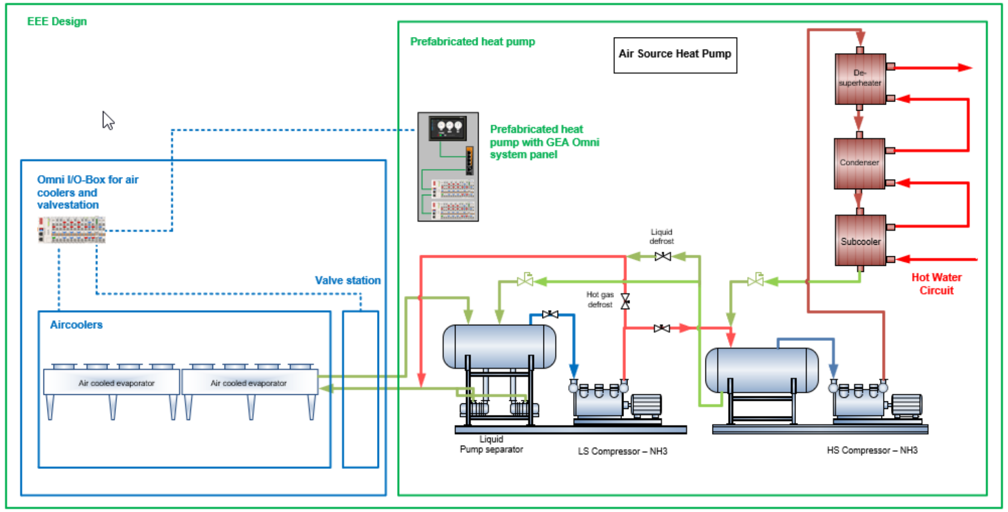
Heating or Drying by means of heat pumps



ASHP – AIR SOURCE HEAT PUMP

Illustration of generic 10MW airsource heat pump

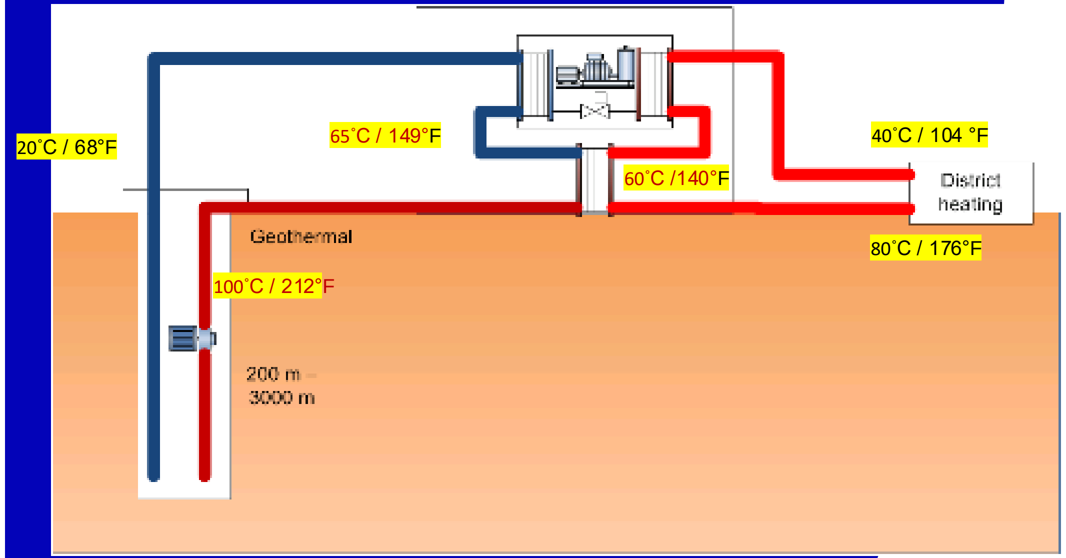




Development project

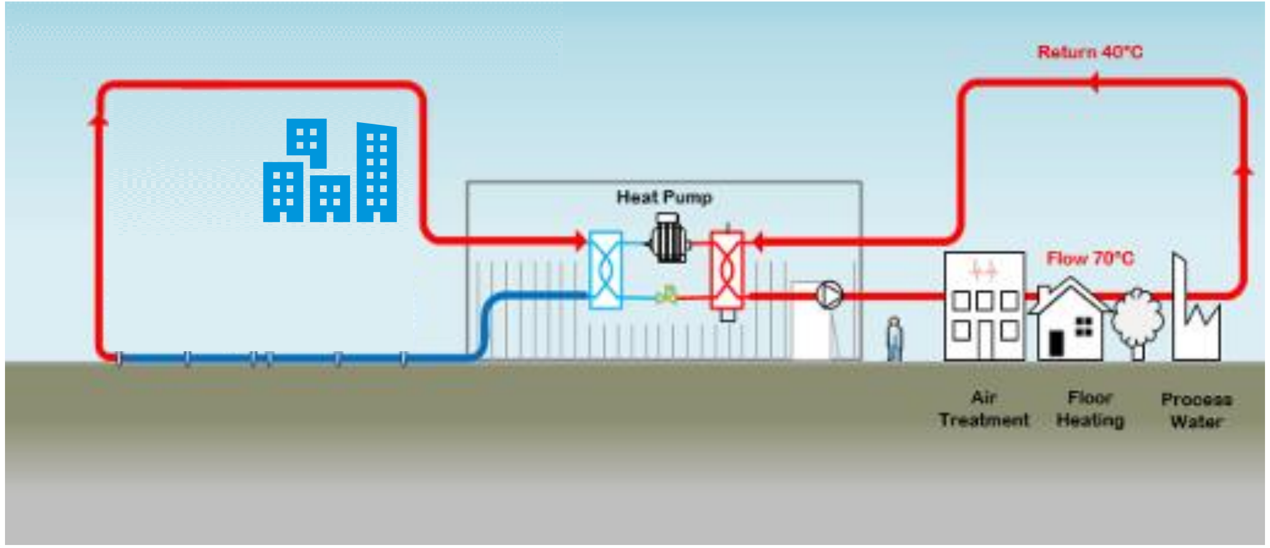
- Air source heat pump with direct ammonia
- With liquid ammonia defrost
  - Full heating capacity during defrost period
  - Almost zero energy required for defrost

GSHP - GEOTHERMAL SOURCE HEAT PUMP



DEEP GEOTHERMAL HEAT

COMBINED HEATING AND COOLING



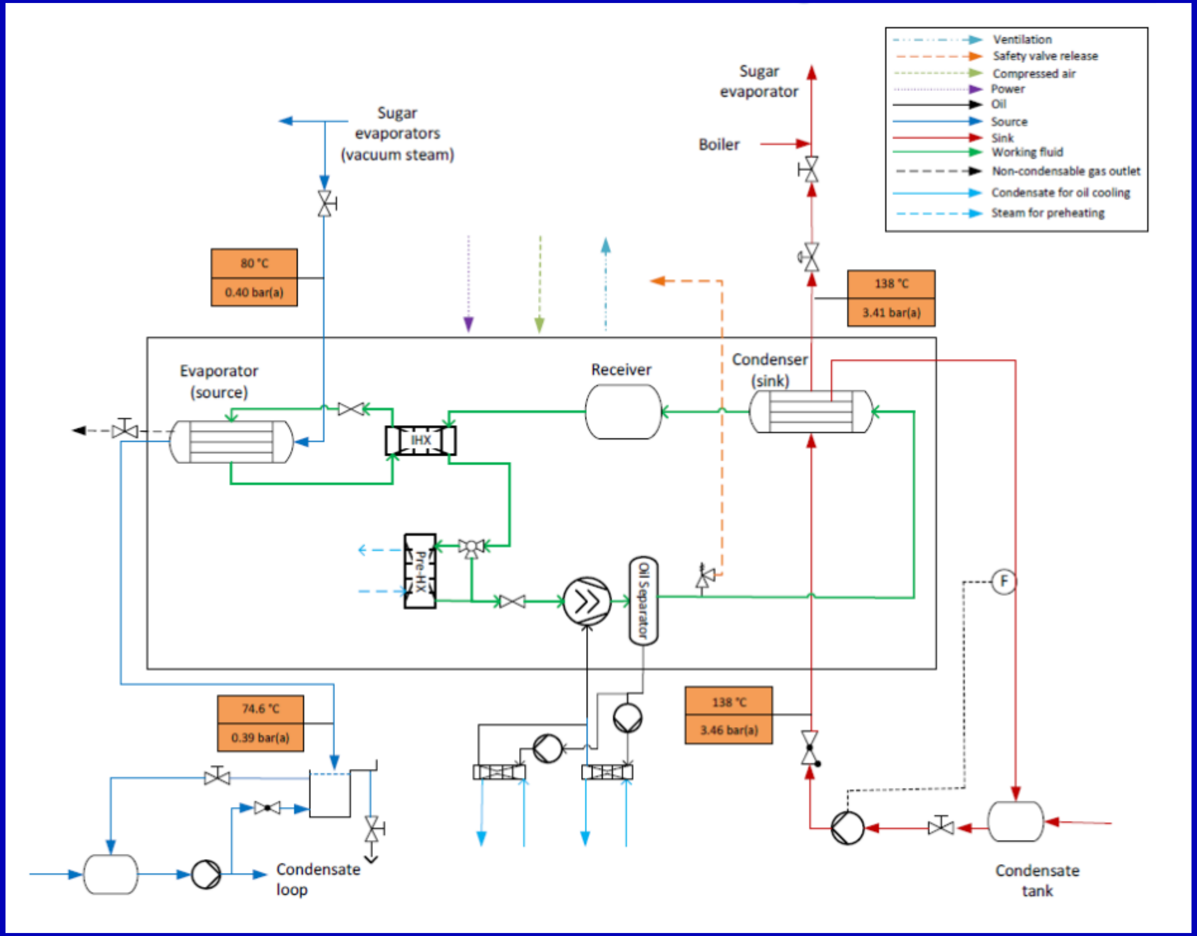
GEA

Decarbonize steam

SUSTAINABILITY

Steam / Heat Pump / n-Pentane Refrigerant (R601) / Demo Site /Belgium

Sugar Production Process Plant



MVR (Mechanical Vapor Recompression) (Recompress Steam)
Open Type Heat Pump

Vapor Recompression (MVR)

Steam generated at low pressure from closed-type heat pumps can be re-compressed by means of an MVR to increase in pressure and temperature

MVR can raise the pressure up to <275 psig), other combined technologies can go higher.

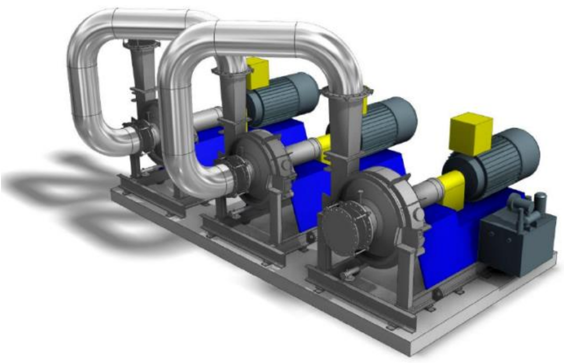
Typical Feed Temperatures at an MVR

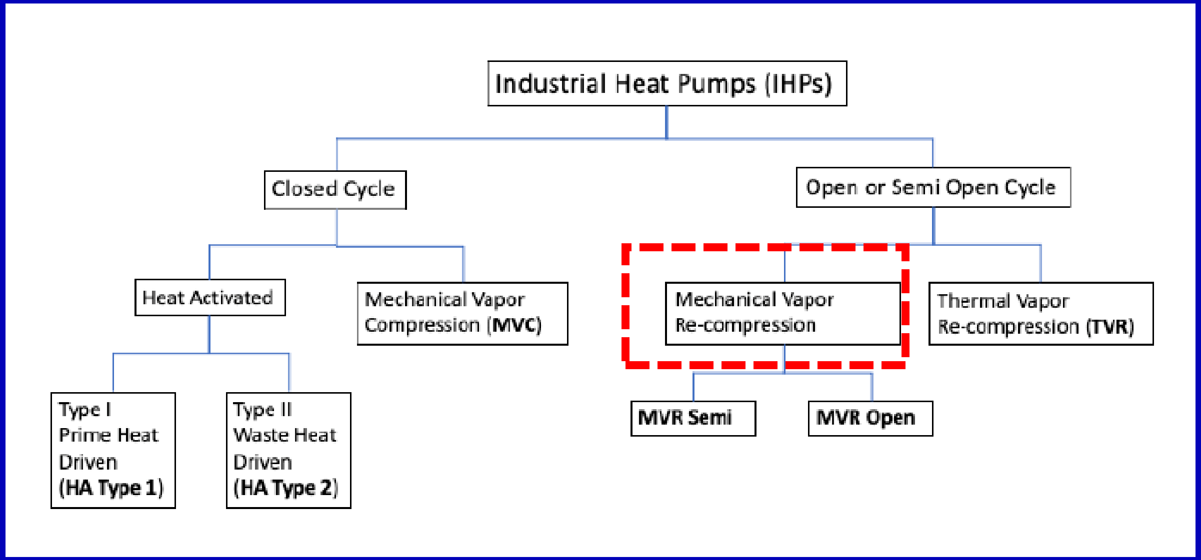
120° F or 48.8° C

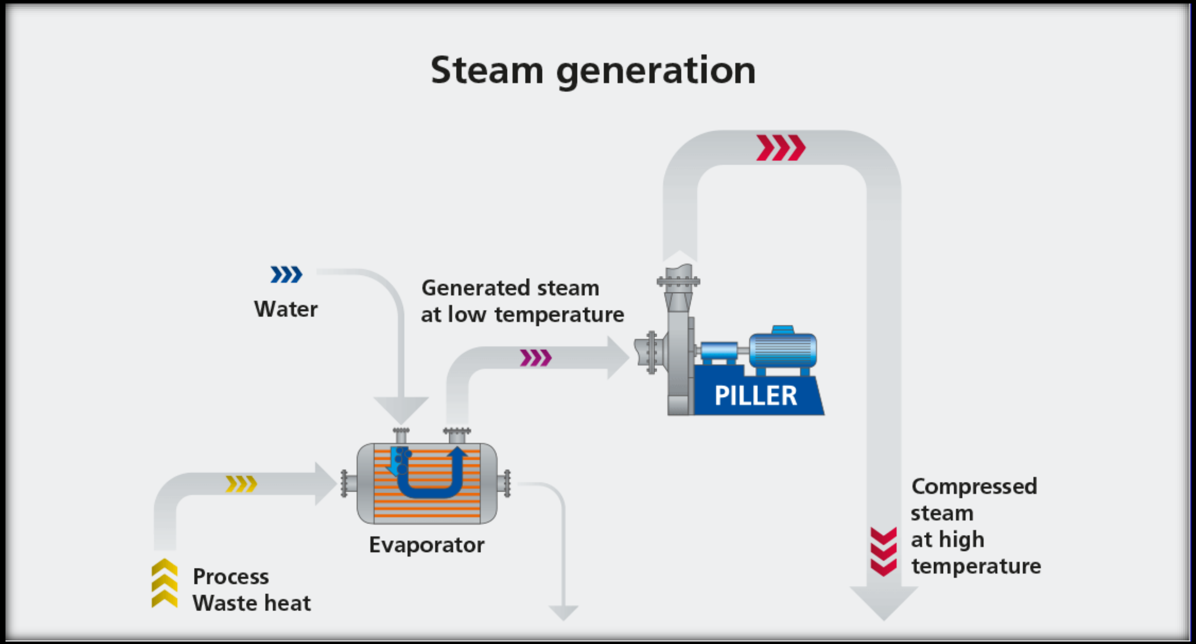
140° F or 60° C

170° F or 76° C

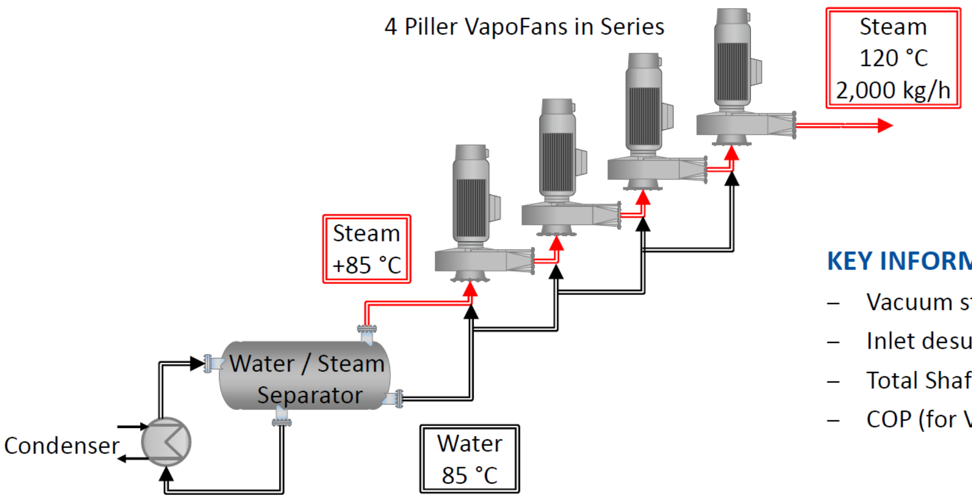
The higher the hot water inlet to the MVR, the better the COP of the MVR.





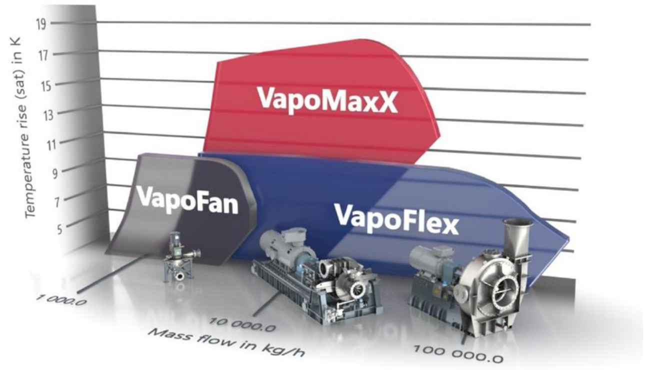


VAPOR FANS – VACUM STEAM RECOMPRESSION



KEY INFORMATION

- Vacuum steam compression
- Inlet desuperheating
- Total Shaft Power: 189kW
- COP (for VapoFans Only): 6.02



Performance ranges for steam at 100 deg C inlet temperature

MVR – VAPOR FANS

Water has a change of state to Steam, in an exchanger or container that is in Vacuum (negative pressure)

Vacuum is created by the Steam Fan

Depending on conditions, each Steam Fan lifts on average 8°C to 10°C

Fan number or steps depends on final temperature

1st Fan lifts from 85°C + 10°C = 95°C

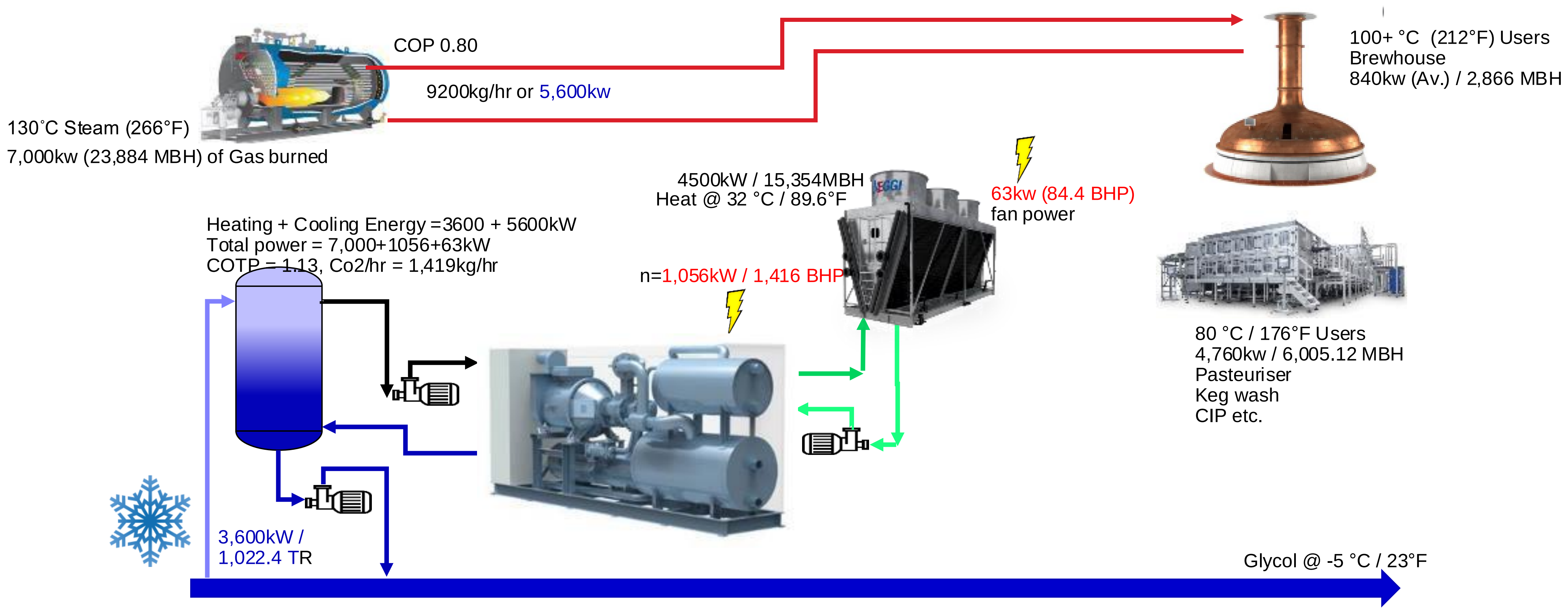
2nd Fan lifts 95 °C + 10 °C = 105 °C

3rd Fan Lifts 105 °C + 10 °C = 115 °C

4th Fan Levant 115 °C +10 °C = 125 °C

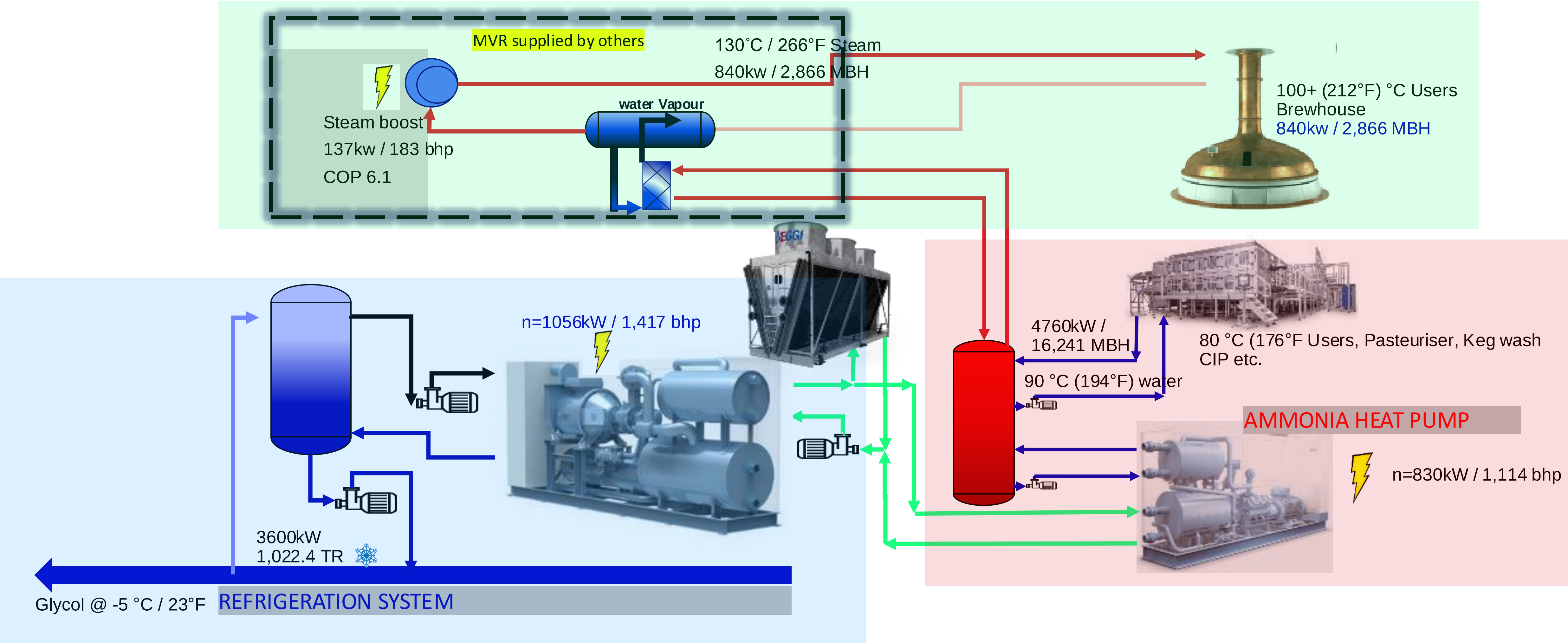
The Norm in brewery

Boiler = Heat, Cooling = Cold



Hot water and steam

Heating + Cooling Energy =3600 + 5600kW
Total power = 137+1056+830kw
COTP = 4.5, Co2/hr = 158kg/hr

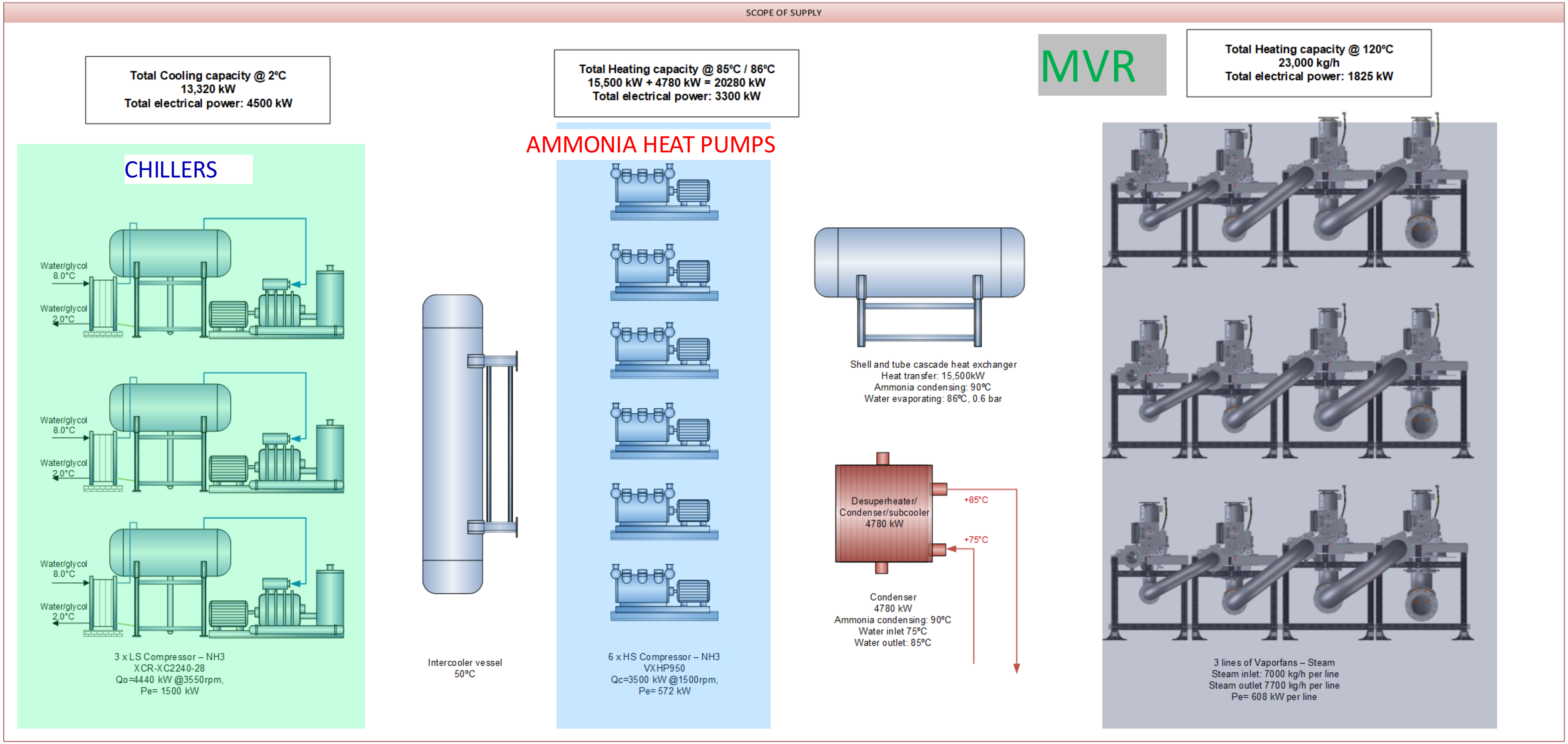


The first steam-producing heat pump has been installed at Felleskjøpet Agri in Trondheim

- ✓ Produces 2 tons of steam per hour
- ✓ Recycles air-sourced waste heat
- ✓ Capacity of 1.4 – 1.8 MW_{th}
- ✓ Efficiency gain of 67%

ANEO

STEAM TEMPERATURES (CHILLERS + MVC+ MVR)



Engineering for a better world.

ADD BETTER CONSULTING

SOSTENIBILIDAD

GEA

Our **organization**

GEA is divided into **five divisions**, each with up to six business units. The units are based on comparable technologies and have leading market positions.

The **country organizations** stand ready to serve their respective customers as a central point of contact, offering them local access
to an extensive portfolio of products and services.

GEA NEXUS

Add Better: Holistic Solutions

GEA Expertise from all Divisions, incorporated to customer process

Engineering for a better world.

BARRIERS of heat pumps

WHY STILL SO HARD IN THE USA TO GET INTO A HEAT PUMP ??

Despite the great ecological potential, there are still some market barriers to the wider spread of industrial HTHPs:

Lack in the understanding of the HTHP technology (low level of awareness of the technical possibilities among users, consultants, investors, plant designers, producers, and installers).

Lack of knowledge about the integration of HTHPs in industrial processes.

Cost-intensive integration into existing processes due to tailor-made designs (leads to payback periods larger than for gas or oil-fired boilers).

Lack of suitable and approved compressors and refrigerants.

Competing heat-producing technologies generating high temperature using fossil fuels.

Low fossil energy prices (low gas to electricity price ratio)

Lack of pilot and demonstration systems.

Lack of training and events additionally supporting the spread of HTHP knowledge

Domestic Manufacturing: Not enough Manufacturers in the US and long lead delivery times (40 -50 weeks) (Who holds the line are Heat Exchanger Manufacturers, they are in the 25-30 weeks lead time).

Utility Pricing Structures Currently utility demand tariffs are structured in such a way that drawing load during peak hours contributes to making electricity a non-competitive input fuel, compared to natural gas.

Insufficient Grid Infrastructure Infrastructure to support the requisite load of electrifying process heat is typically inadequate, including both distribution infrastructure and customer substation and internal wiring.

What makes the USA different from Europe:

Spark Gap or Spark Spread (gas prices & kw prices) are much higher in EU which helps justify the energy savings and pay back

USA does not have yet a CO2 Emission Tax where in EU this factor justify many Heat pumps rather that Spark Gap ratio and Energy Savings.

Europe has learned to switch from Steam to Hot Water

EU has more Gov Funding than US.

GEA

MANY BROWNFIELDS – RETROFITS DO NOT HAVE SPACE FOR HP

CURRENT BARRIERS

SPACE on BROWN FIELDS - RETROFITS

Many companies do not have space in their current Engine Room or Plant.

OUTDOORS

This will force a market for ENCLOSURES

ENCLOSURES becomes Engine room so now it needs to follow all Codes, Fire Codes and any building code related to space, building

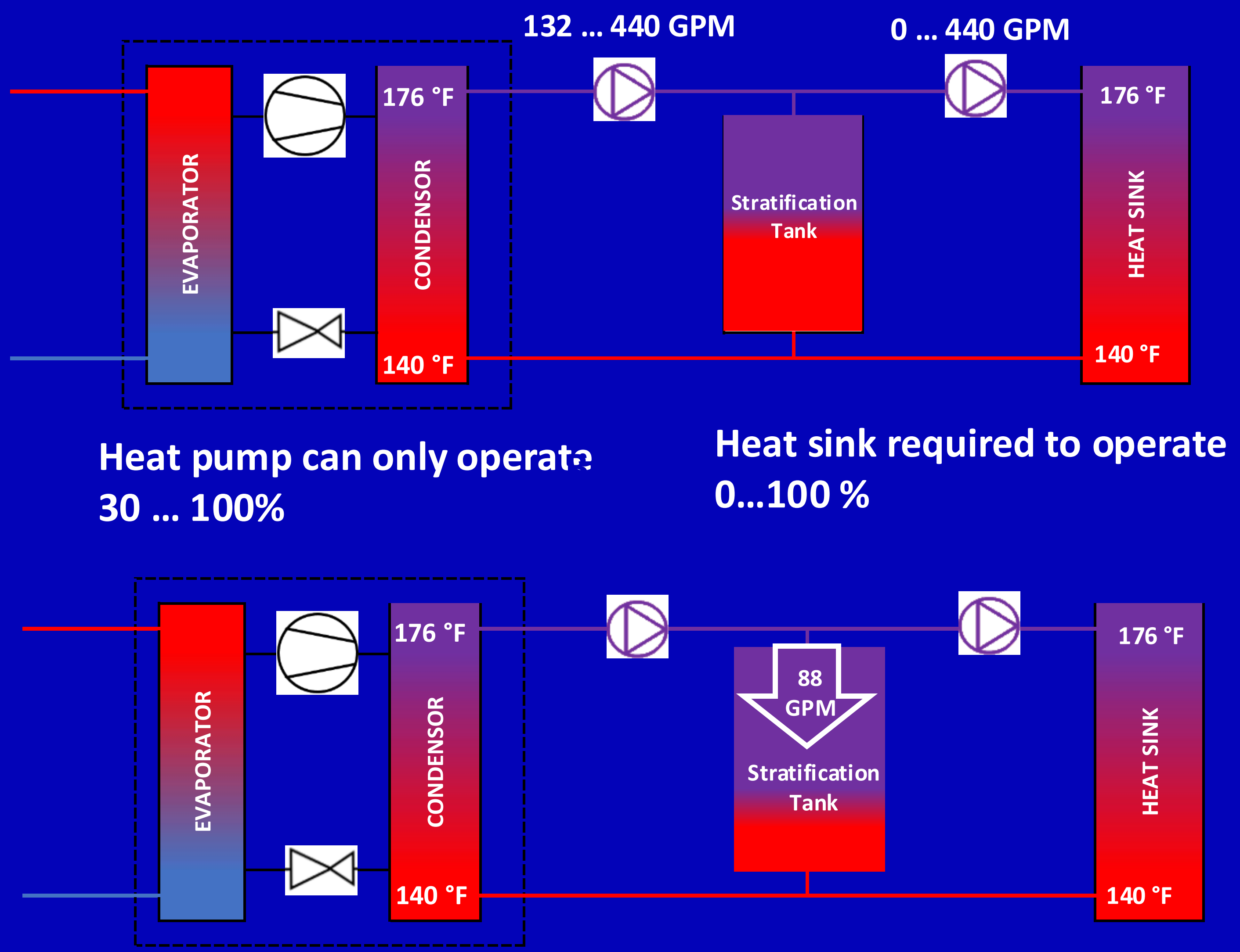
GEA

TES (Thermal Storage Energy) – Buffer Tanks

TES (WATER TANKS)

Handles better:

- Partial load
- Spikes
- Sudden changes
- Provides a more steady / stable operation



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The Dutch Coca-Cola factory has received CO2-neutral certification according to PAS2060

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