

Industrial Heat Pump Technology and Market Assessment

Peoples Gas and North Shore Gas

Technology Evaluation

- Background and Overall Project Objectives
- Introduction to Industrial Heat Pumps
- Technology Evaluation

Background and Overall Project Objectives

The project will address the following:

- High-level introduction to Industrial Heat Pump (IHP) technology and applications
- Technology assessment
 - Identify and evaluate capabilities of IHPs to address industry needs, recovering heat from industrial processes
- Market assessment specific to Peoples Gas and North Shore Gas
 - Identify industrial customers most likely to benefit from use of IHPs
- Economic and Emissions Impact
- Barriers to Implementation
- Recommendations for Pilot Programs



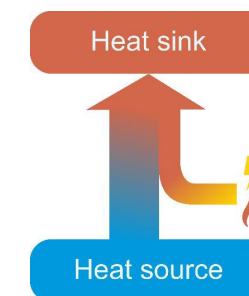
Introduction to Industrial Heat Pumps

Introduction: What is an IHP?

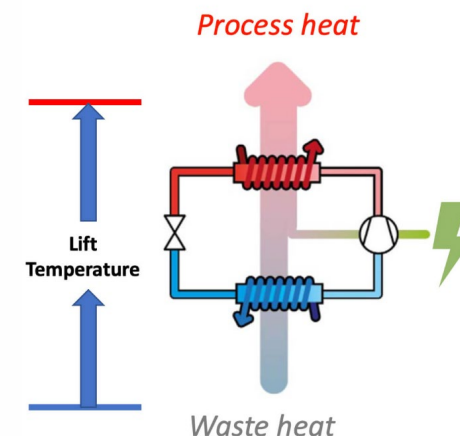
- Moves heat from a lower temperature (heat source) to a higher temperature (heat sink).
 - Primarily uses electricity but can also be steam or heat activated.
- “A class of active heat-recovery equipment that allows the temperature of a waste-heat stream to be increased to a higher, more useful temperature” [DOE, 2014]
- “IHPs are a promising technology that will play a significant role in industrial decarbonization. They work by using electricity to move heat from one location to another, a method that is more efficient than direct heating using electricity or a thermal fuel source. Favorable conditions for heat pumps exist in industrial facilities with low-medium temperature process heating needs than can be matched with available waste heat streams.” [2024, BPA]

<https://www.energy.gov/sites/prod/files/2014/05/f15/heatpump.pdf>

<https://www.bpa.gov/-/media/Aep/energy-efficiency/emerging-technologies/202403-industrial-heat-pump-market-study.pdf>



IEA Annex 58, Task 1
Technology Report

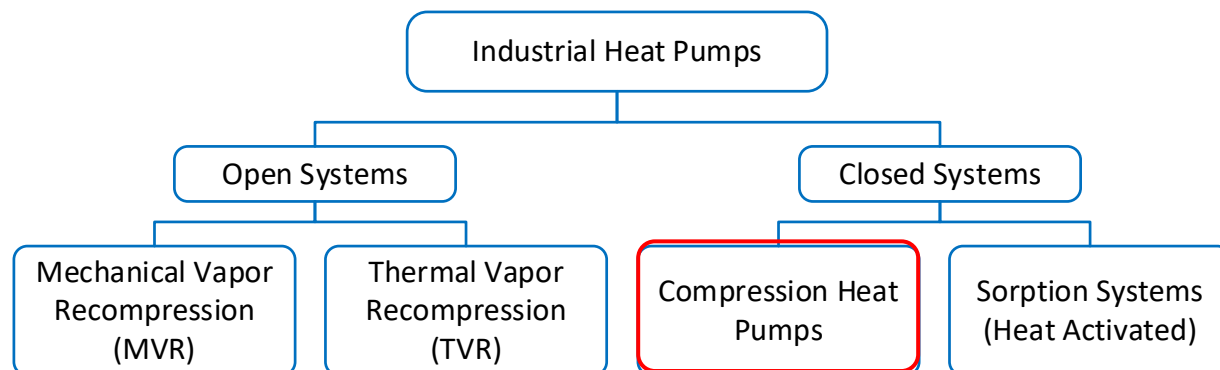


<https://www.aceee.org/industrial-heat-pumps>

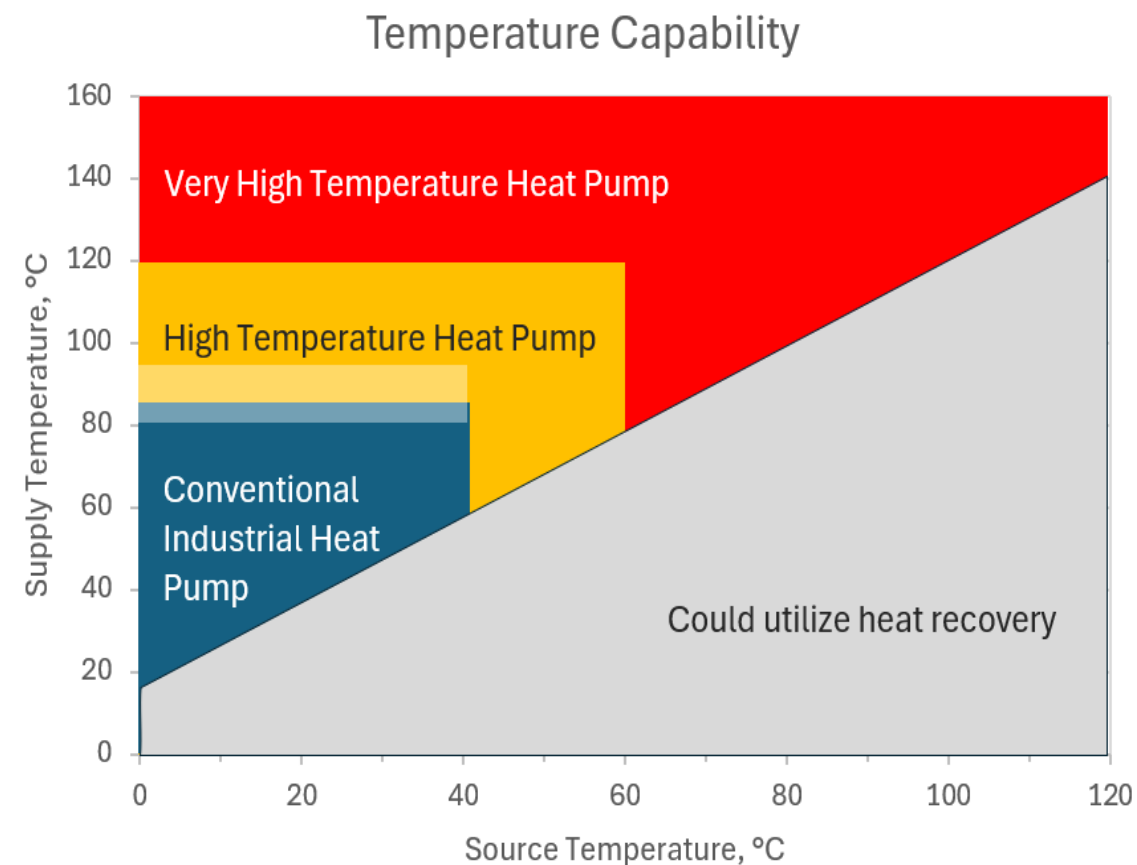
Classification of IHPs

- Wide variety of Heat Pumps—both type and temperature capability.
- This study will largely focus on Compression Heat Pumps
- For this study, temperature ranges are defined as:
 - Conventional Heat Pumps: to 85°C
 - High Temperature: to 120°C
 - Very High Temperature: above 120°C

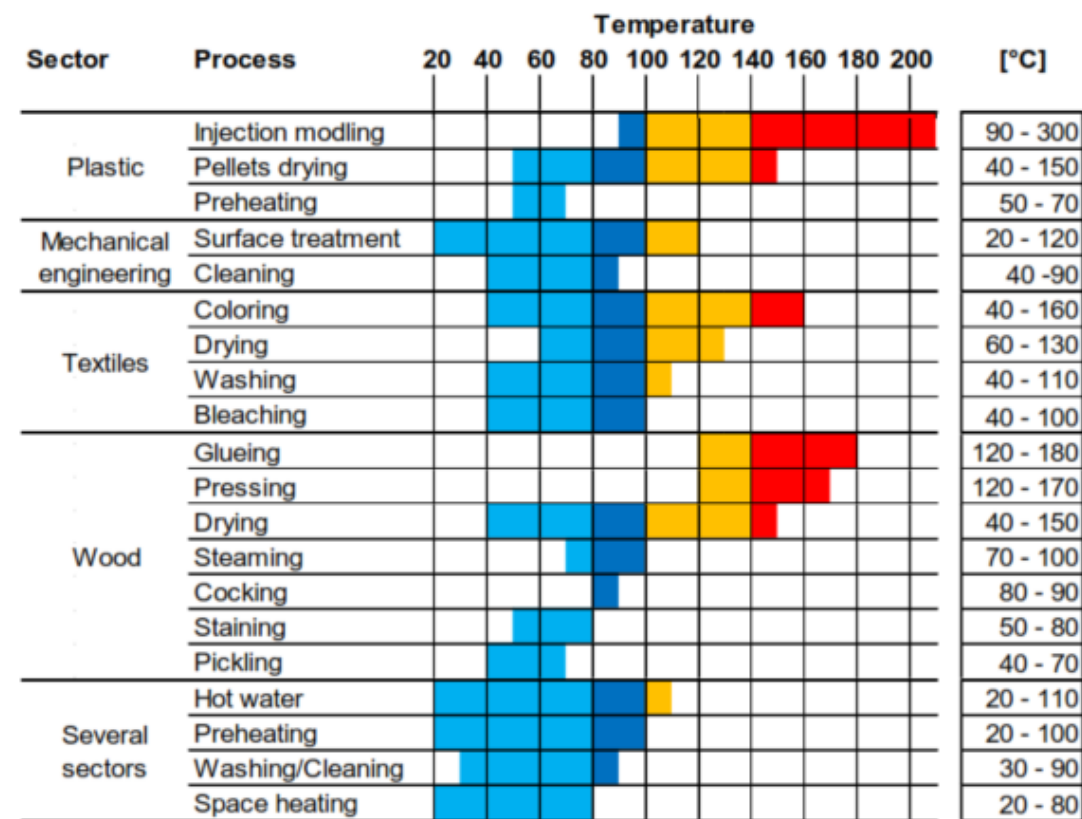
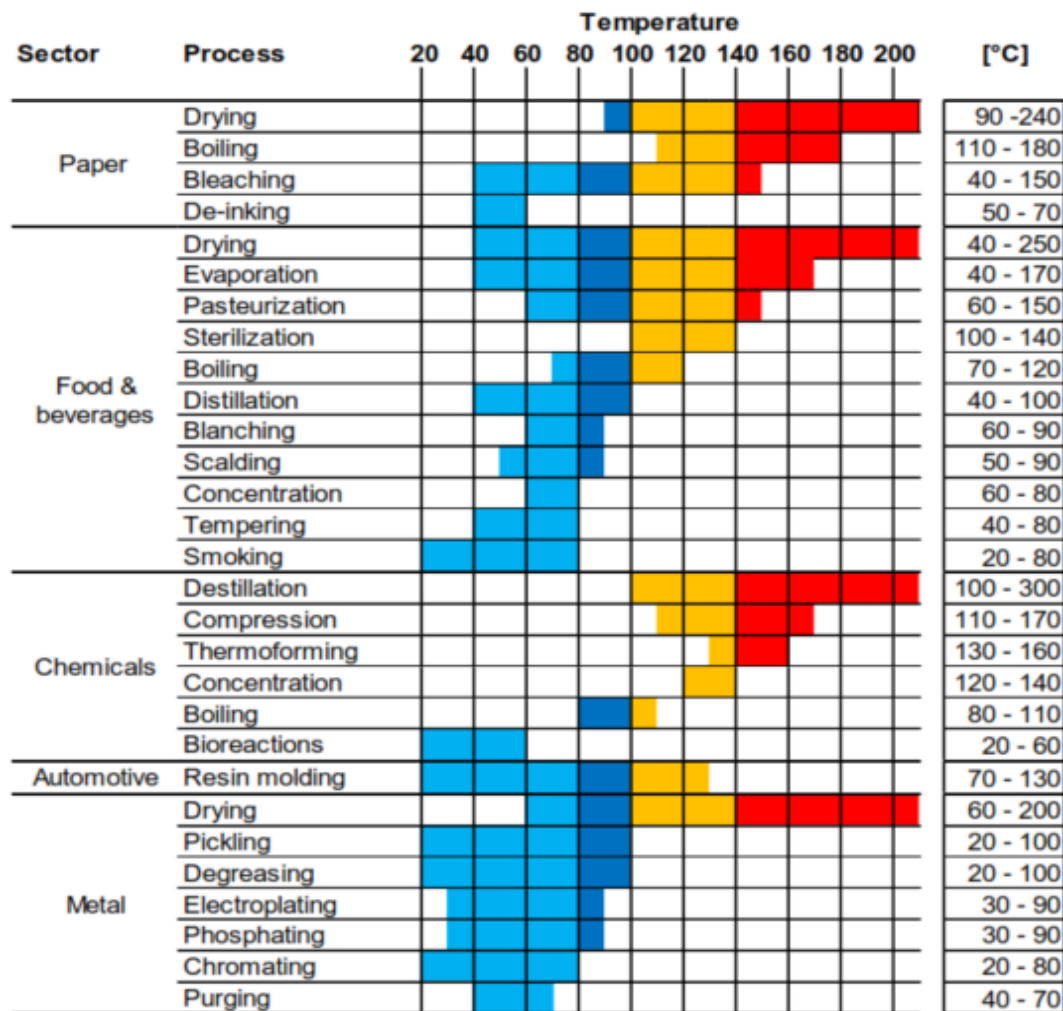
Types of IHPs



C. Arpagaus et al. / Energy 152 (2018)



Industries and Applications



Technology Readiness Level (TRL):

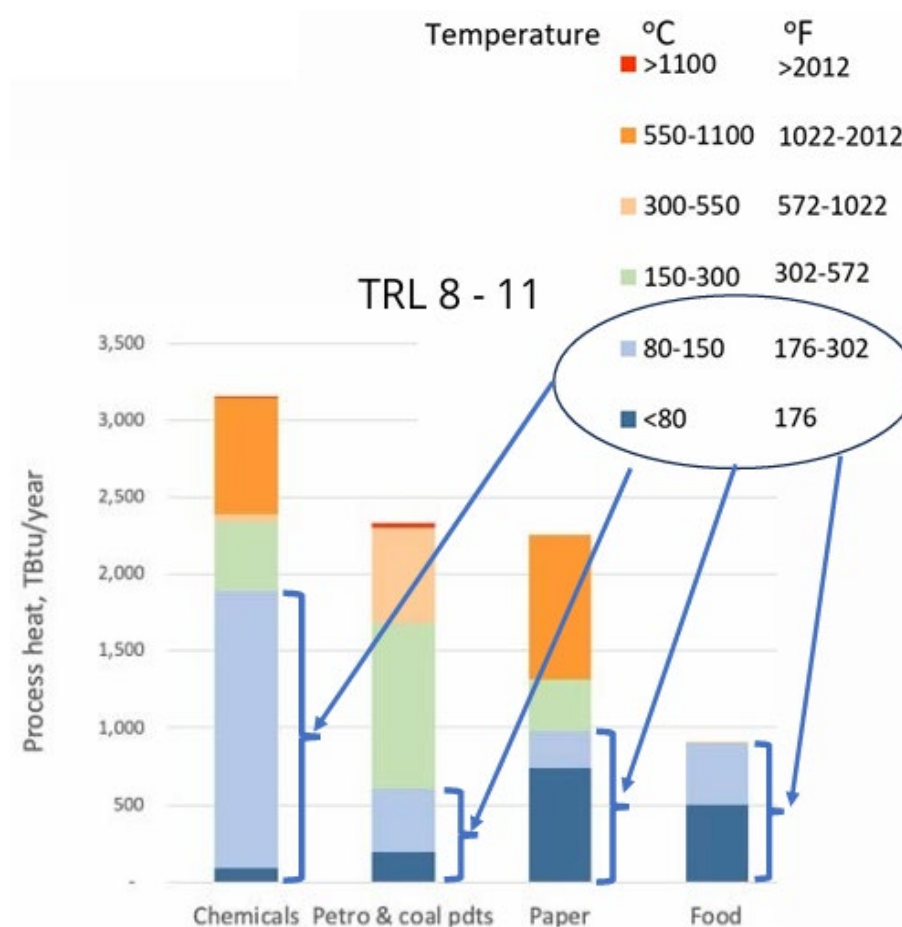
- conventional HP < 80°C, established in industry
- commercial available HP 80 - 100°C, key technology
- prototype status, technology development, HTHP 100 - 140°C
- laboratory research, functional models, proof of concept, VHTHP > 140°C

Applications and Technology Readiness

Table 1.2 ▶ Industrial heat pump technology readiness by temperature range

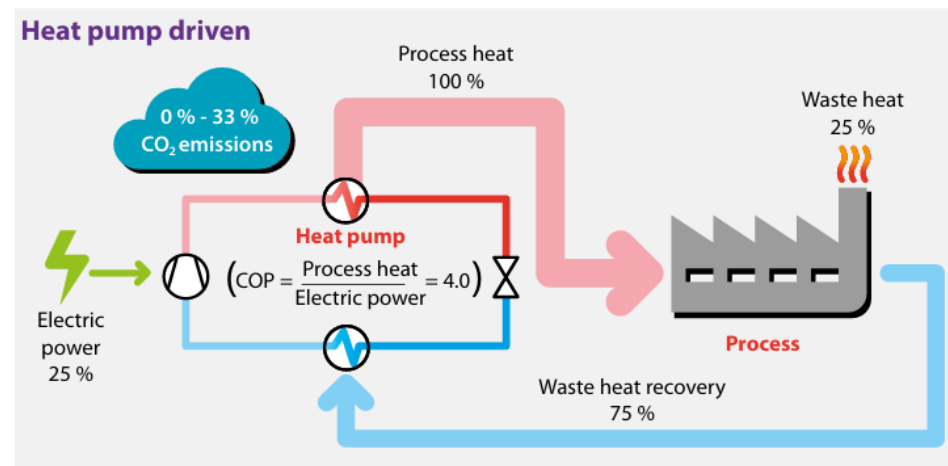
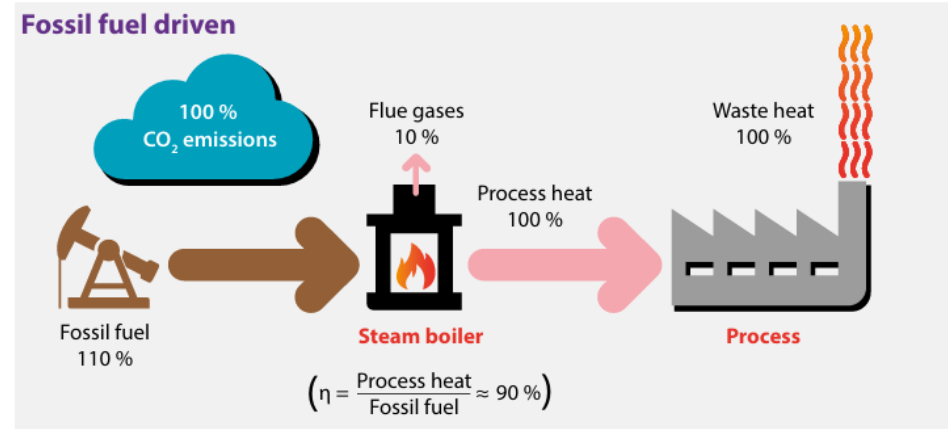
Temperature range	Technology readiness level (TRL)	Example process
<80 °C	TRL 11: Proof of market stability	Paper: De-inking Food: Concentration Chemical: Bio-reactions
80 °C to 100 °C	TRL 10: Commercial and competitive, but large-scale deployment not yet achieved	Paper: Bleaching Food: Pasteurisation Chemical: Boiling
100 °C to 140 °C	TRL 8-9: First-of-a-kind commercial applications in relevant environment	Paper: Drying Food: Evaporation Chemical: Concentration
140 °C to 160 °C	TRL 6-7: Pre-commercial demonstration	Paper: Pulp boiling Food: Drying Chemical: Distillation Various industries: Steam production
160 °C to 200 °C	TRL 8-9: First-of-a-kind commercial applications for small-scale MVR systems and heat transformers TRL 4-5: Early to large prototype	Various industries: High-temperature steam production
>200 °C	TRL 4: Early prototype	Various industries: High-temperature processes

Readiness level: ● TRL 1 to 5 ● TRL 6 to 7 ● TRL 8 to 11



Why Now?

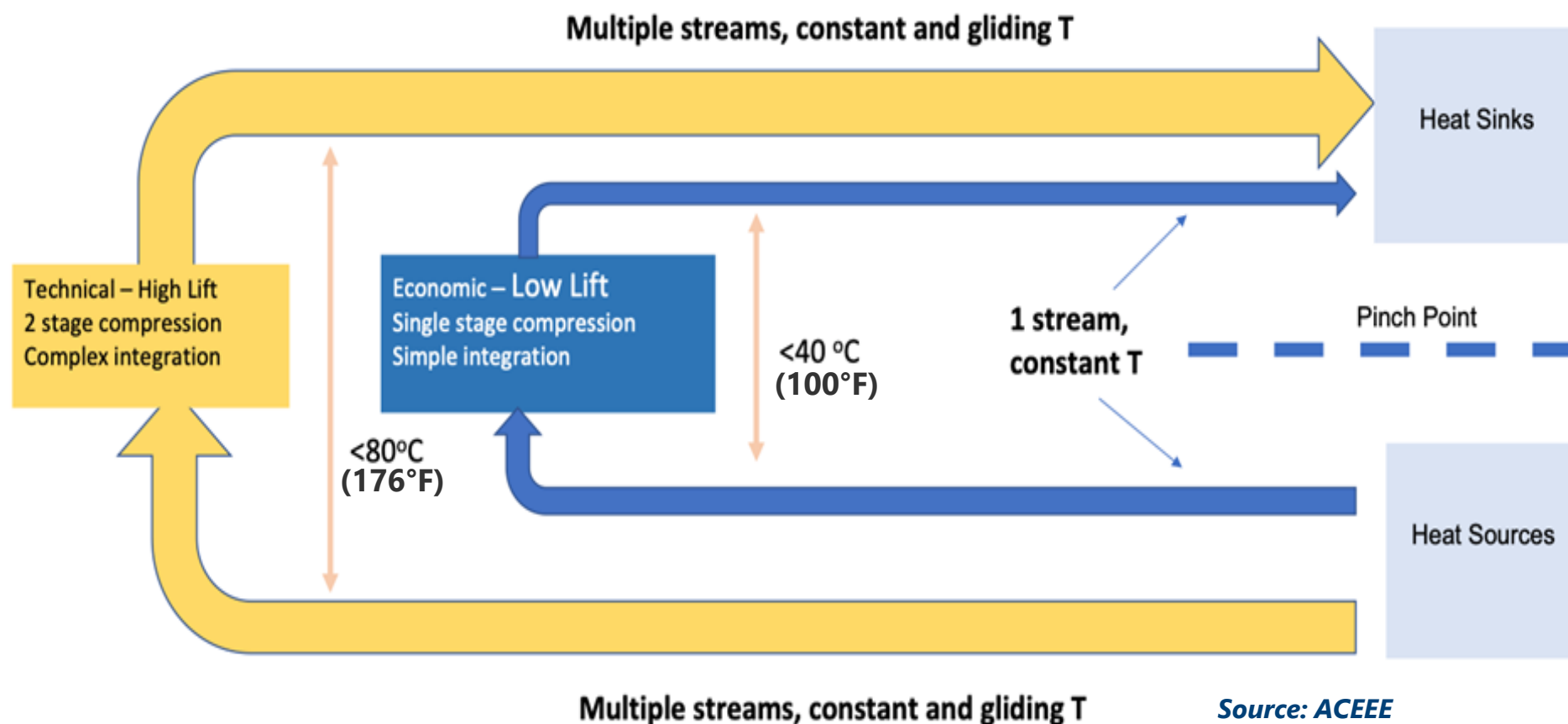
- IHPs can reduce the total end use energy input by a factor of 2 to 5, depending on the process COP.
- No site emissions. Offers the potential of zero emissions when using renewable electricity.
- Helps in achieving corporate carbon reduction sustainability goals
- For many applications, IHPs are a mature technology with commercial vendor offerings in the U.S.
 - Higher temperature applications are being developed and prototyped.



<https://www.sintef.no/globalassets/sintef-energi/industrial-heat-pump-whitepaper/2020-07-10-whitepaper-ihp-a4.pdf>

Single-stage vs Two-stage compression

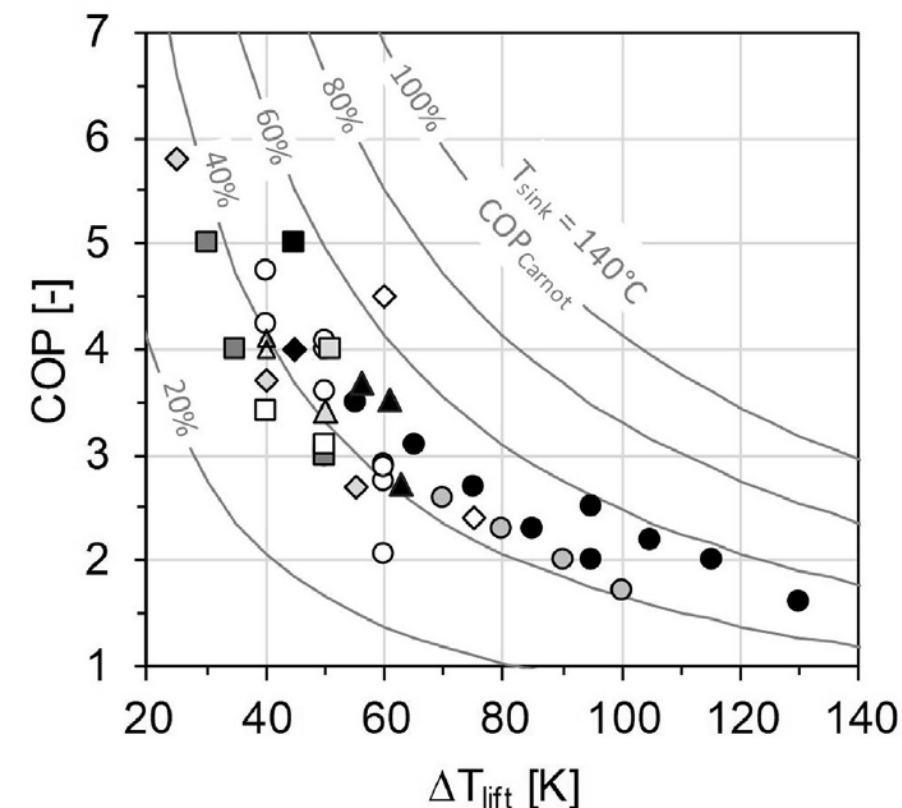
- Single-stage with lower temperature lift is higher efficiency and less complex



Source: ACEEE

COP vs Temperature Lift

- Overall COP is limited to 100% Carnot Efficiency
 - Practical performance in the range of 50% Carnot
- Higher temperature lifts result in lower COPs
 - Consequence is that optimal performance is based on higher source (waste heat) temperatures
 - Low source temperatures and high sink (supply) temperatures result in low COP



C. Arpagaus et al. / Energy 152 (2018)



Technology Evaluation

Major U.S. Vendors of Industrial Heat Pumps

- Focus on suppliers with U.S. service support and domestic production (prioritized)
 - This significantly reduces the vendor supply. For more complete listing of non-domestic suppliers, see [IEA Annex 58, Task 1](#)
- Limiting to suppliers with installation experience beyond demonstration or pilot sites
 - Exception to be AtmosZero given the unique solution
- For High Temperature Heat Pumps, focus on closed-loop IHPs in the 0.5-10 MWth range. Most likely solution for food and beverage, chemical sectors and hospitals.
- For conventional Heat Pumps, review all ranges. Likely solution for larger district heating systems.

[GEA](#)

[Armstrong
International](#)

[Trane](#)

[Multi-Stack](#)

[Copeland /
Vilter](#)

[Atmos Zero](#)

[JCI/York](#)

IHP U.S. Vendors Today by Supply Temperature

Conventional Heat Pump - Up to 85°C (185°F)

- GEA, Multistack, York/JCI, Trane, Vilter/Copeland,

High Temp Heat Pump (HTHP) - Up to 120°C (248°F)

- GEA, Armstrong Intl, Vilter/Copeland, Trane (future)

Very High Temp Heat Pump (VHTHP) - Above 120°C (248°F)

- Vilter/Copeland (SPH acquisition), AtmosZero
- More Commercially Available in EU

GEA



- Legacy in cooling and heat recovery for over 160 years
- Based in Germany with strong U.S. market presence (Columbia, MD)
 - Produce GEA Omni, packaging units, chillers and heat pumps
 - 13,000 m² facility with 205 U.S. employees
- Has a full range of heating and refrigeration technologies:
 - Compressors and packages
 - Custom-engineered systems
- Focus on ammonia systems (natural refrigerant with zero GWP)

GEA Heat Pump Products

Product Portfolio Overview

GEA Systems North America - HRT



GEA Product Line: Blue=Refrigeration;
Red=Heat Pumps; Grey=Custom Systems

GEA ammonia heat pumps incl. Fusion

Overview portfolio GEA North America

GEA RedGenium



Standard reciprocating compressor heat pump

- 7 types, 2 compressor models (V HP, V XHP)
- Max. +203°F/+95°C
- Approx. 850 ... 8400 MBH¹⁾
250 ... 2500 kW
- Best-in-class efficiencies
- Most sustainable solution (ecologic and economic)

GEA RedAstrum



Standard screw compressor heat pump

- 7x M types, 1x L type
- Max. +185°F/+85°C
- Approx. 850 ... 10000 MBH¹⁾
600 ... 3000 kW
- Robust, low-vibration screw compressor for high temperature lifts

GEA Blu-Red Fusion



Standard Blu chiller / Red heat pump combination

- All combinations of Blu and Red modules possible
- Approx. 850 ... 8400 MBH²⁾
250 ... 2400 kW
- Unique flexibility with different operation modes

Custom heat pumps



Customized reciprocating and screw heat pumps

- All suitable compressors
- Approx. 850...34,000MBH³⁾
250...10,000kW
- Tailor-made single and multi-stage systems

1) (+95/86 °F | +122/ 158 °F); (+35/30 °C | +50/+70 °C) 2) (+52/43 °F | +122/ 158 °F); (+12/+6 °C | +50/+70 °C) 3) (+52/43 °F | +122/ 158 °F); (+12/+6 °C | +50/+70 °C)

GEA Heat Pump Overview 2025 - GEA North America

9/25/2025 10

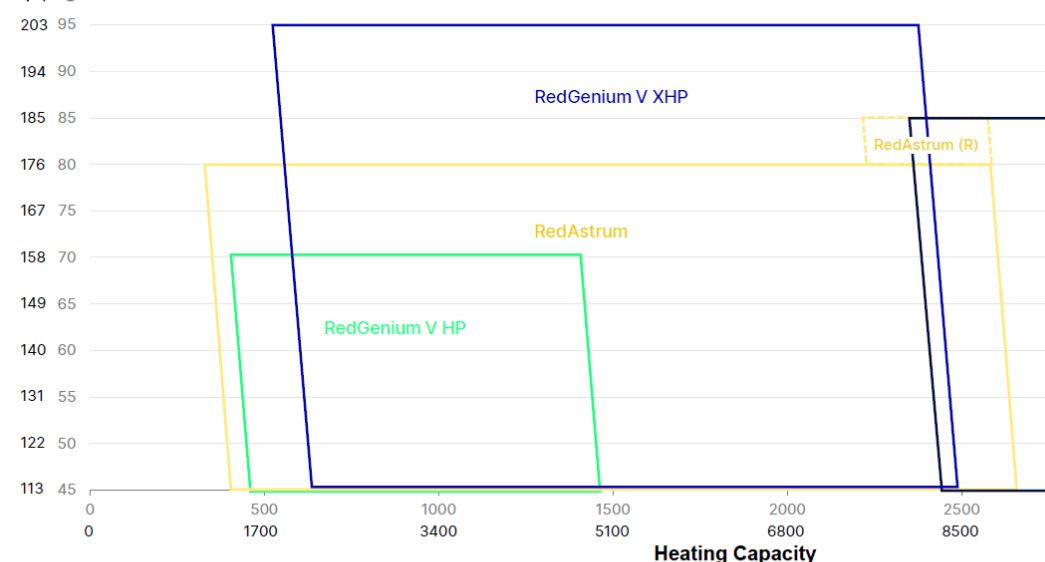
GEA Heat Pump Products

GEA ammonia heat pump range

Temperature – capacity application range:

Heat sink temperature

°F / °C



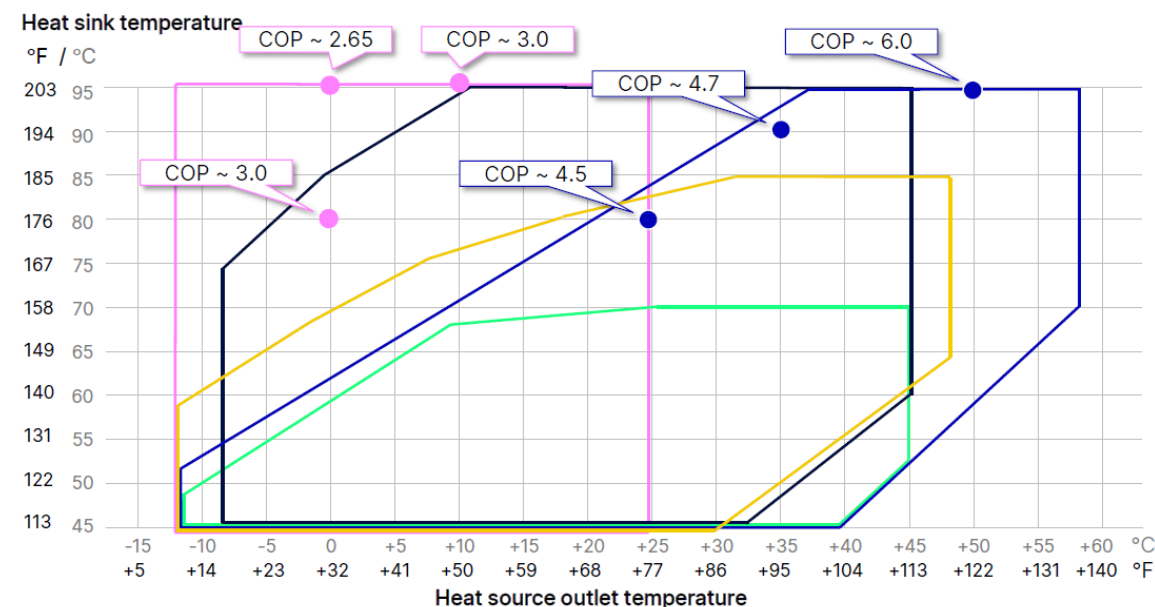
- Capacities are indicated approximately for a heat source temperature level of approx. +95 °F/ +35 °C supply. Lower temperatures provide less capacity.
- With sufficiently high-temperature heat source, e.g. +113 °F/ +45 °C, heat sink supply temperatures up to +203 °F/ +95 °C are possible with the V XHP.

GEA Heat Pump Overview 2025 - GEA North America

Temperature – Capacity Range
(standard products)

Temperature-application diagram

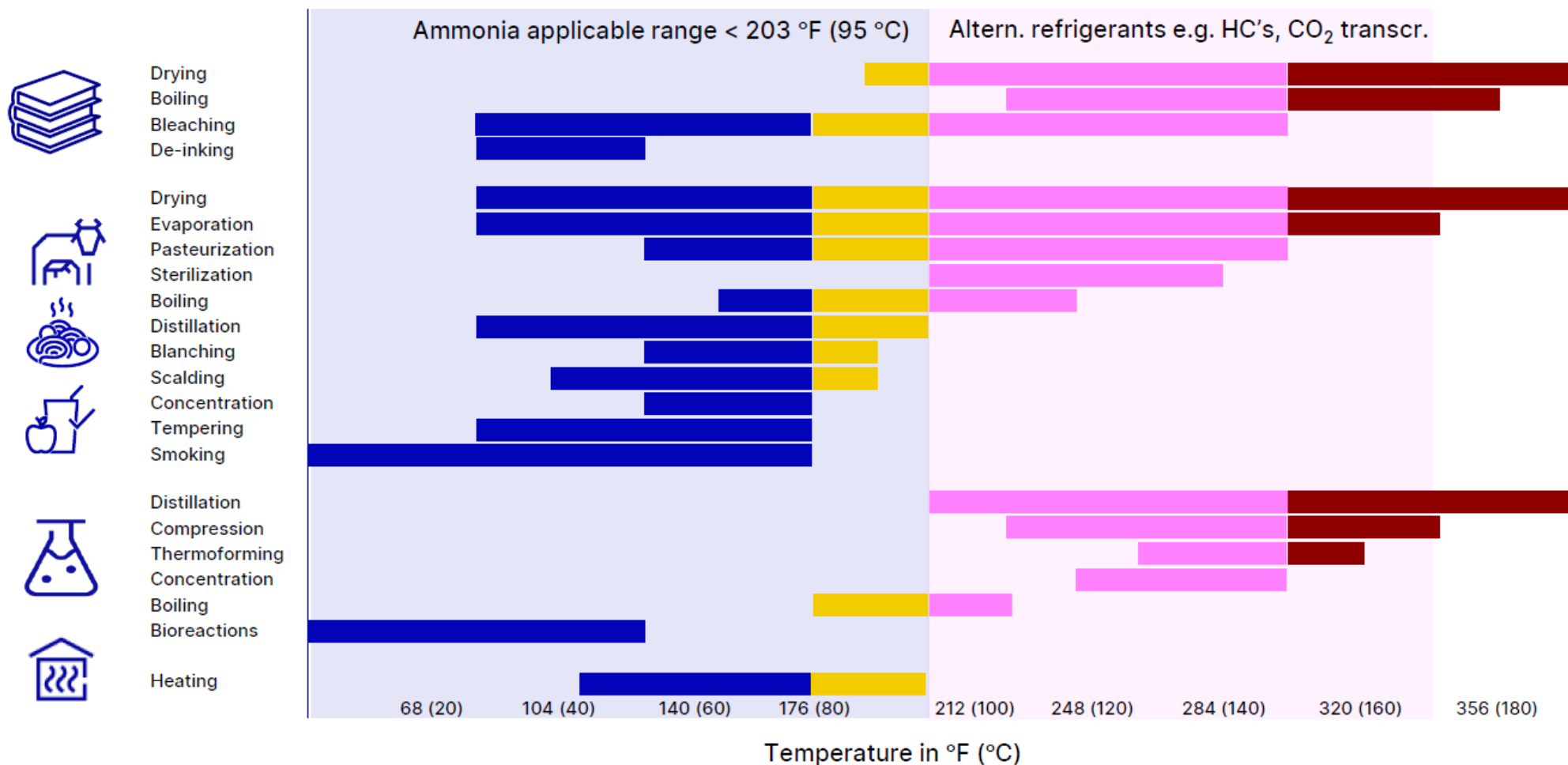
Approximate chart for all GEA heat pumps incl. COP



RedGenium V HP RedGenium V XHP RedAstrum Custom with L XHP 2-stage: Custom Blu-Red Fusion

Application Temperatures
(with COP)

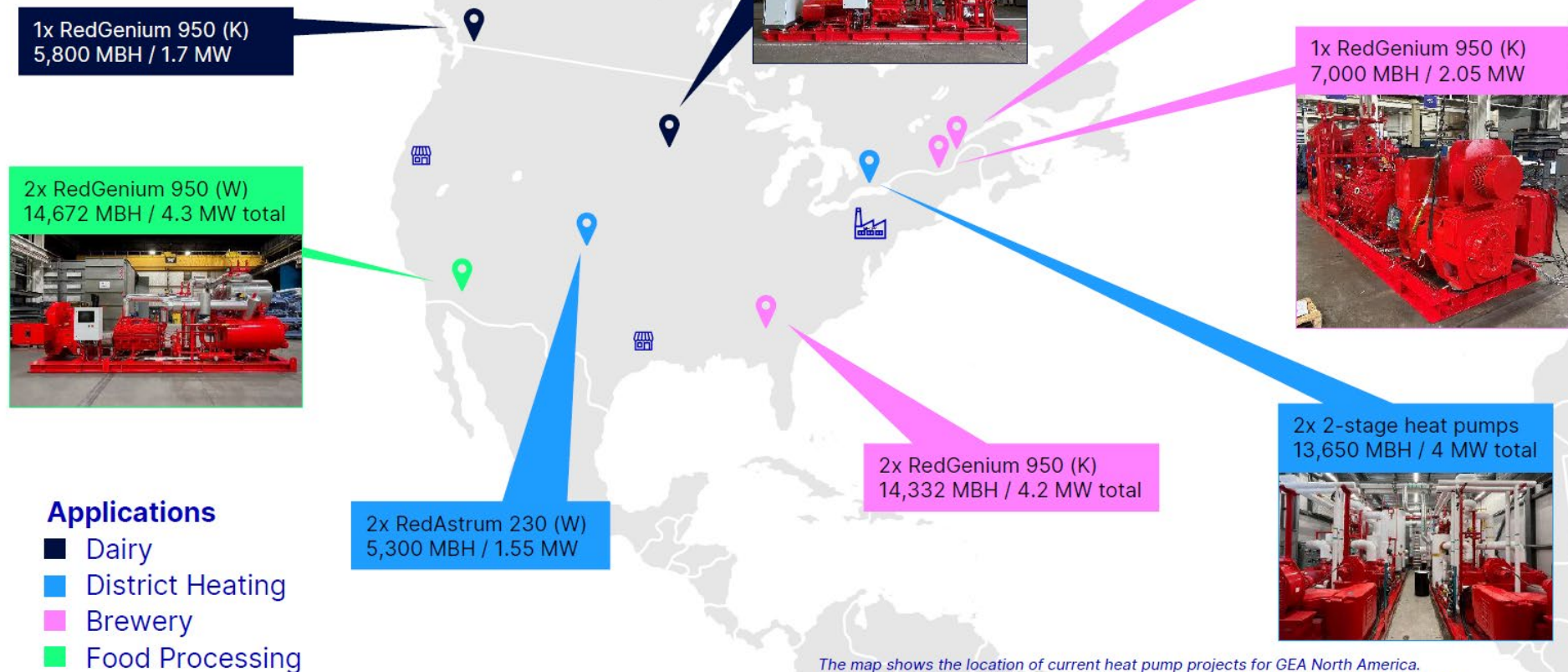
GEA – Process Experience



GEA – North American Installs

GEA heat pumps references

Overview GEA North America



Applications

- Dairy
- District Heating
- Brewery
- Food Processing

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).



Armstrong International



Armstrong International

- Company founded in 1900 with strong expertise in thermal systems, with specialties in steam distribution in a wide range of industries: chemical, food & beverage, pharmaceutical, healthcare, building energy management
- Headquarters in Three Rivers, MI
- Global footprint with more than 3000 employees
- Licensing agreement since 2017 with CombiTherm, a German heat pump manufacturer
- Currently expanding the Michigan plant for industrial heat pump production

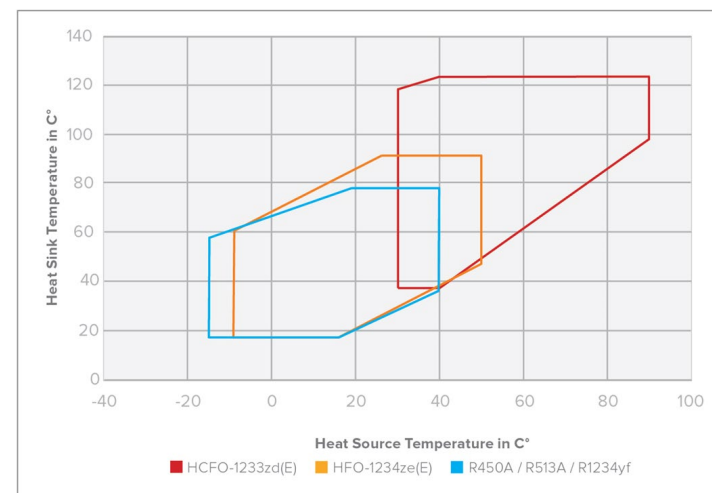
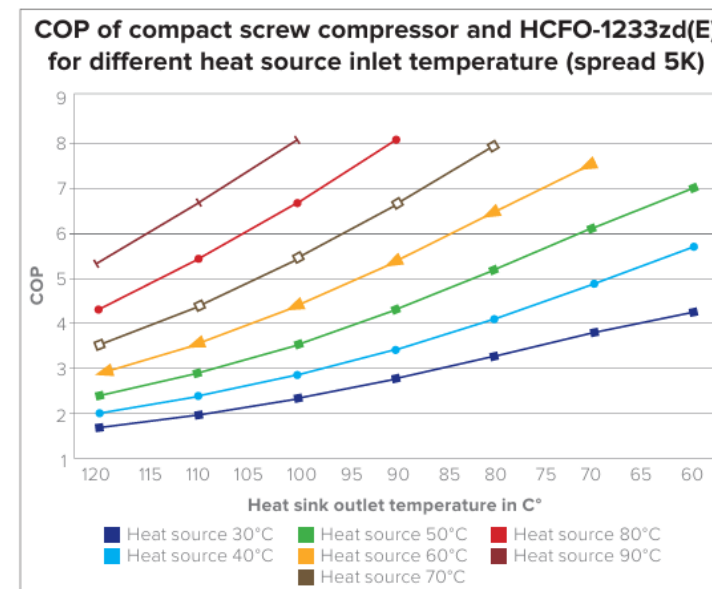
Armstrong International

- Armstrong has historical experience and complete product line for steam solutions. <https://armstronginternational.com/>
- Expanding manufacturing capability in Three Rivers, Michigan for production of Industrial High Temperature Heat Pumps. [Announcement](#)
- Performance testing capability being added at the plant.
- Have placed emphasis on advancing both current and future technologies
- Have implemented “Circular Thermal” approach, balancing energy efficiency, waste heat recovery and heat pumps. [Armstrong Circular Thermal](#)



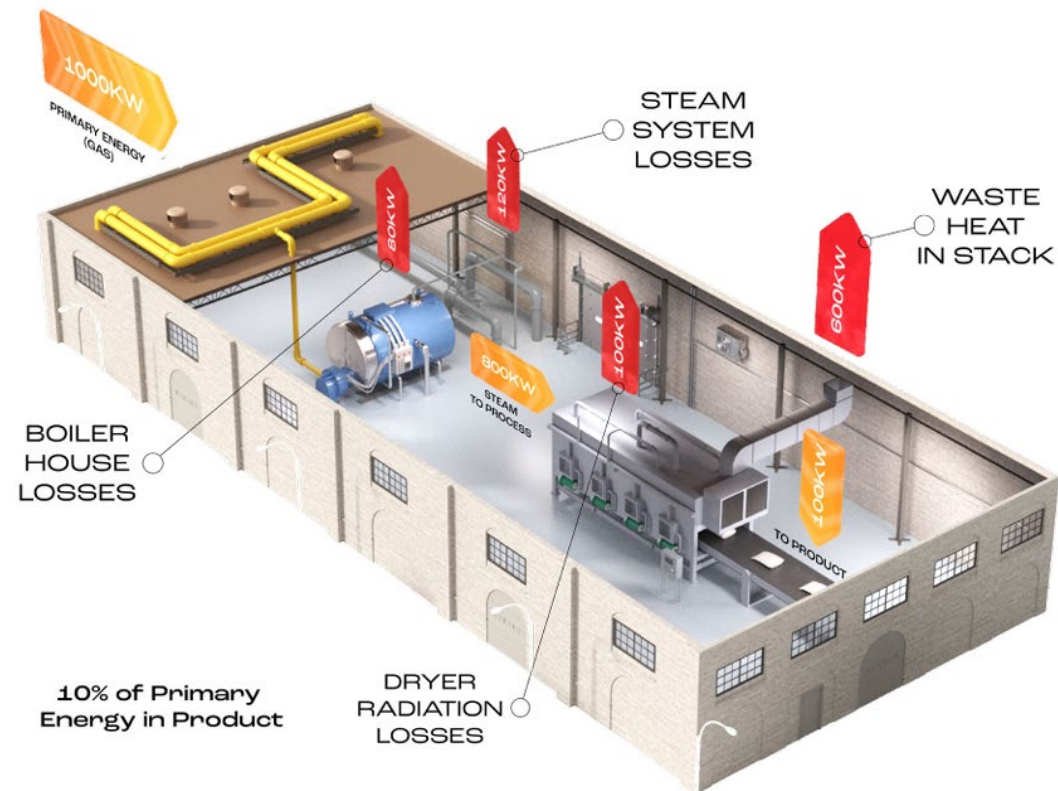
Armstrong International

- Industrial Heat Pump products:
 - Based on licensing agreement with CombiTherm (dozens of installs in Europe and India)
- Current product line offers 248°F hot water, with plan for low pressure steam production in the near future.
- Available using several low-GWP synthetic refrigerants and both piston and screw compressors.
- Capacity of 300-1500 kW_{th}, a range suitable for many food & beverage plants.

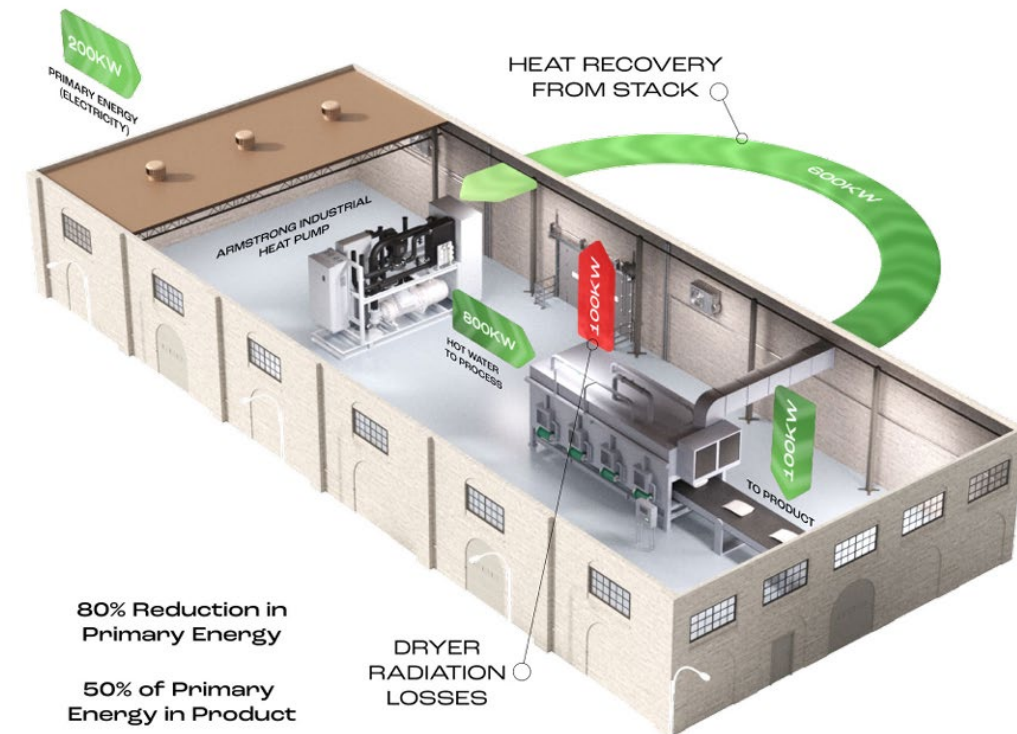


Armstrong Facility

Standard One-way Thermal System—Single Process User



Circular ThermalSM System—Single Process User



tronginternational.com

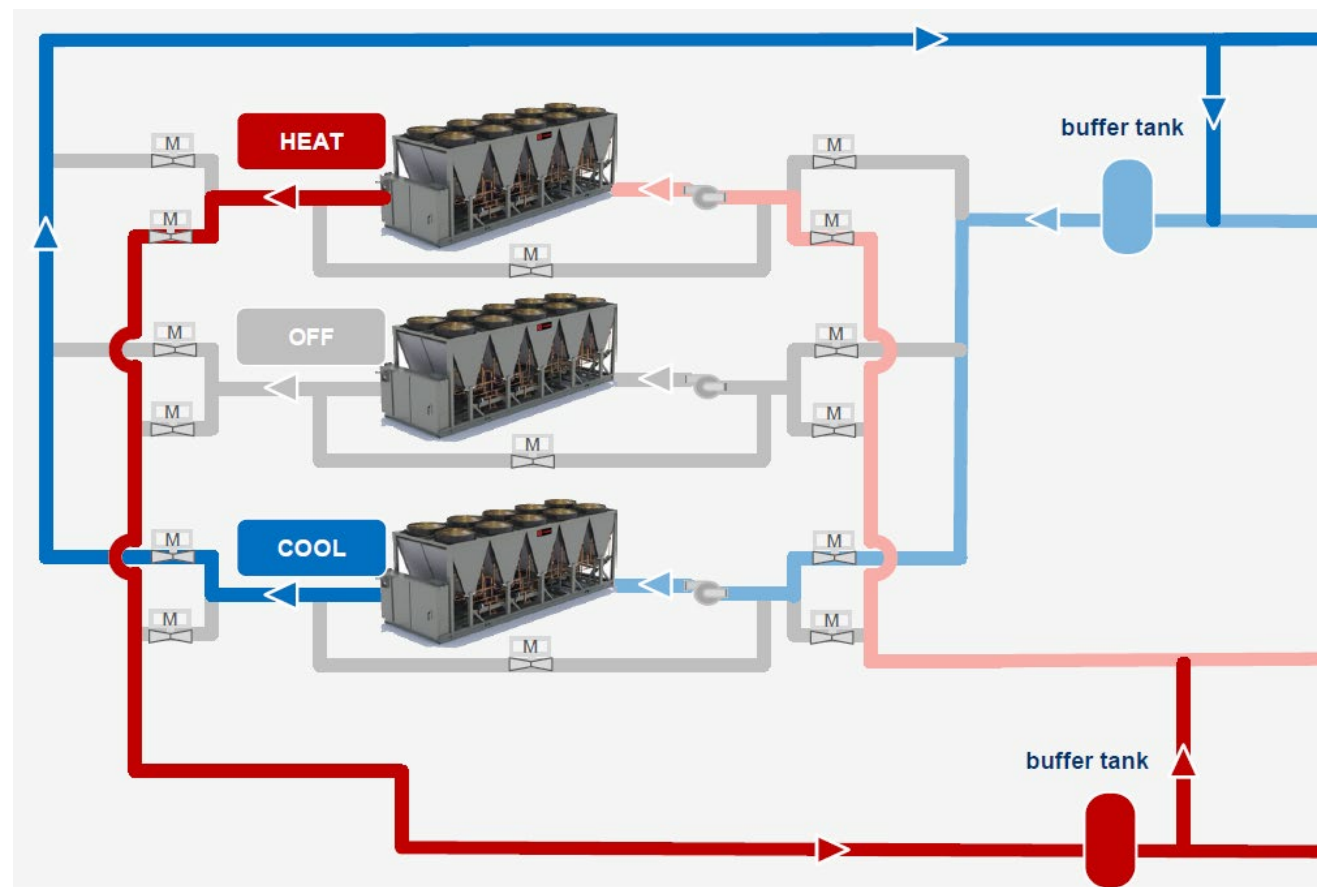
Trane



- Manufacturer of HVAC systems with strong presence in building management systems
- Employs 29,000 people, 104 manufacturing facilities in 28 countries
- History of chillers; thermal storage and more recently heat pump systems

Trane – Current Air-to-Water Heat Pumps

- Operate for cooling or heating
- Ideal for warmer climates; limited in cold climates
- Temperatures up to 165°F, generally below that needed for industrial applications



- High-temperature heat pump as Engineer to Order (ETO) product
- Current temperature capability is 210°F, with future expectation of 250°F.
- This offers heat at temperatures more commonly needed by industry

Project Example: Low Capacity - RTZA

Available Today via ETO



Base Product: RTWD, 2 Circuit Machine with Screw Compressors

Refrigerant: R1233zd, 1 GWP

Unit Capacity: 2900 to 3100 MBH

Max Lift: 130F (80F LEWT to 210F LCWT)

Motor/Starter: 460V/575V, 60Hz, Fixed Speed Unit Mounted Starter

Minimum heat load $\leq 30\%$ at full lift

NYSERDA – prequalified heat recovery solution

- The CVZA is larger capacity (to 35,000 kBtu/h) at temperatures to 180°F and lift of 80°F
- Potential solution for district heating applications

Project Example: High Capacity - CVZA

Available Today via ETO



Product/Footprint: Same as CVHH with 2 Stage Compressor

Unit Capacity: 11,000 to 35,000 MBH

Motor/Starter: 4160V, 60Hz, Remote AFD/Autotransformer

Refrigerant: R514A (140F to 180F Leaving Condenser Temp)

Minimum Heat Load <= 25% @ Full Lift

Max Lift: 80F (100F LEWT to 180F LCWT)

Certification: UL, cUL, ASME

Future Options (ETO): Dual Bundle Condenser, Duplex unit

MultiStack



MultiStack

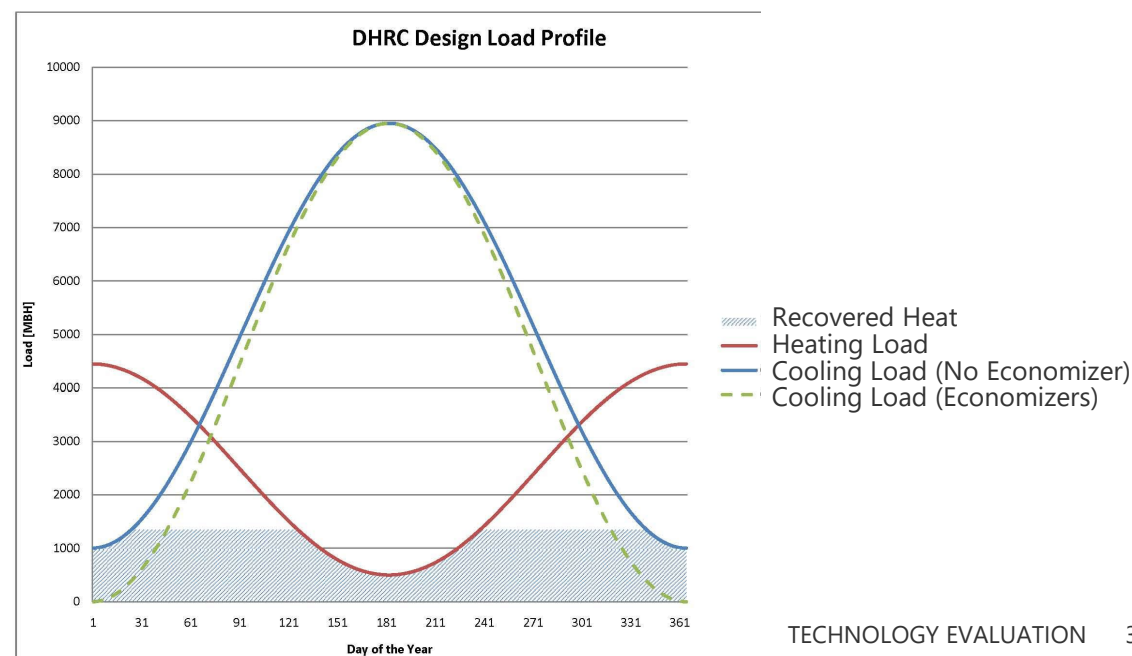
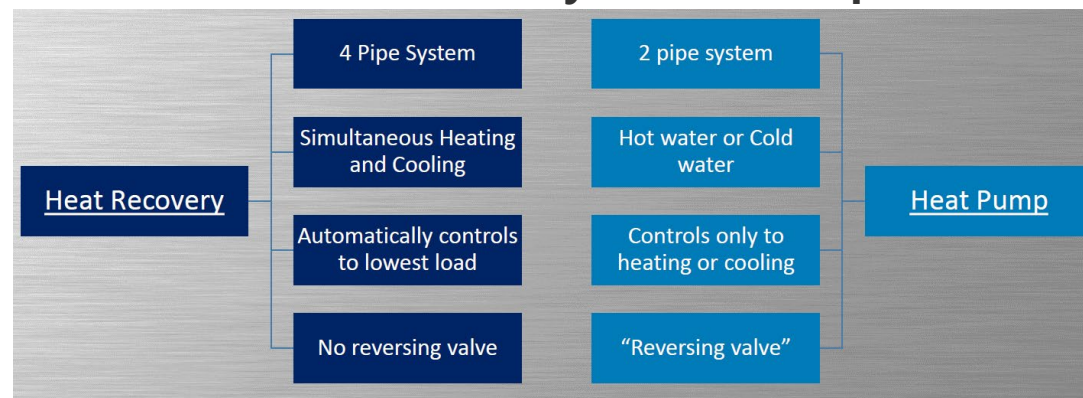
- Founded in 1989, Sparta, WI
 - Key talent with chiller experience (from Trane)
- Developed the modular chiller; the first to use the TurboCor magnetic bearing compressor
- Leader in developing a dedicated heat recovery chiller (simultaneous heating/cooling system)
- Up to 180°F supply water temperature
- Equipment likely a good fit for building systems but limited to industrial applications requiring lower temperature (<180 F)



MultiStack Heat Recovery Chillers

- Packaged systems to provide heat recovery for simultaneous loads
- Example of Indiana hospital application using heat recovery chiller.
 - Saved 40,000 Therms NG annually
 - \$50,000 Energy Savings/yr
 - 300 Metric Tons CO2 reduction

Heat Recovery vs Heat Pump



MultiStack

Product Line

- MSH_M Modular Chiller
 - 65-120 Ton modules, Water to 145°F
- DHRC Modular Chiller
 - 15-1,320 Tons (with multiple modules)
 - Hot water to 175°F
 - Heating COPs over 3.0; Combined COPs of up to 7.0
- VME II
 - Central Station Chiller-Heater
 - Custom, engineered design





Vilter by Copeland

COPELAND

VILTER
by **COPELAND**

Vilter by Copeland

- Vilter is a strong presence in the industrial refrigeration industry
- History of ammonia heat pumps, in the past limited to 80-85°C
- Presently expanded to 95°C with new product
- Recently acquired SPH Sustainable Process Heat, a German company leading the development of steam-generating heat pumps.

Vilter New Product, VQ95

- Targeting district and process heating (likely the food and beverage industry)
- Capable of 95°C (203°F) with high temperature rise
- Capacity of 1-5 MWth per skid with balanced single screw compressor
- Currently being installed in Canada for waste water heat recovery
- Industrial application being installed in U.S.



Key Industries served by the VQ95:



District heating



Food and beverage



Industrial manufacturing



Pulp and paper



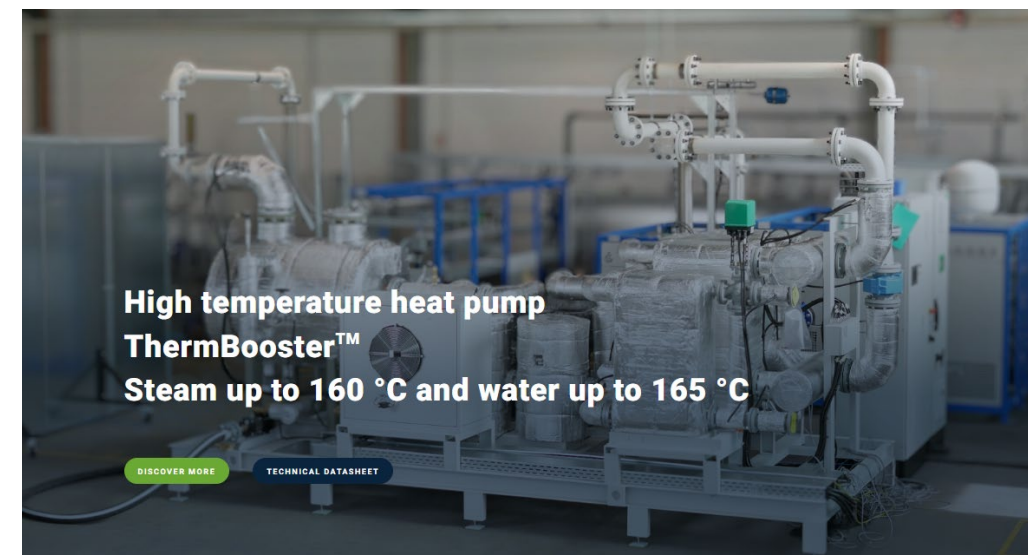
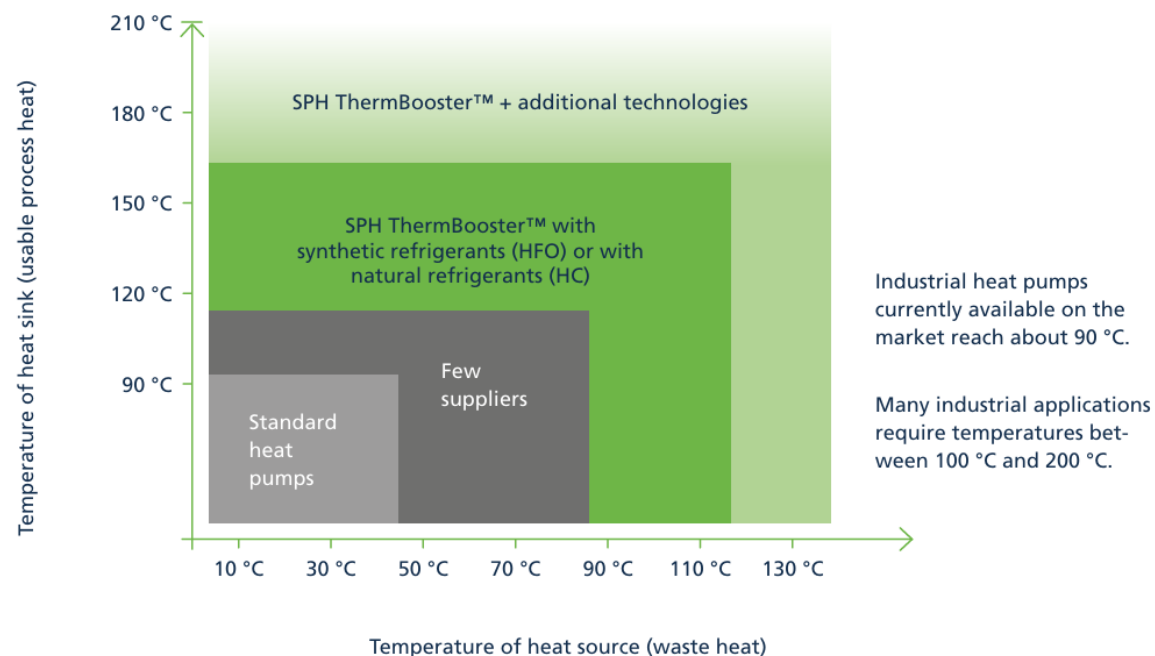
Pharma



Chemical

New addition to Copeland

- Acquisition of SPH Sustainable Process Heat announced October 23, 2025
- A key addition for domestic high temperature heat pumps
- Several commercial installations and pilot at very high temperature (165°C)

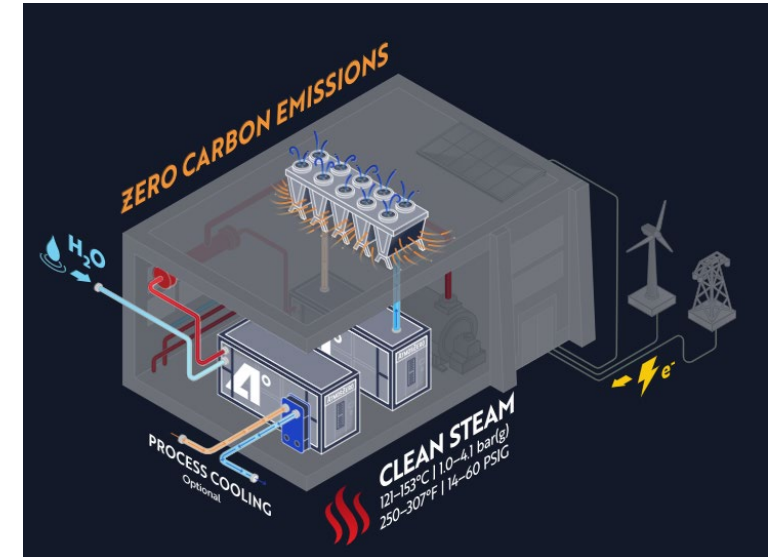


AtmosZero



AtmosZero

- AtmosZero is a newer company located in Colorado.
- Spin-off of Colorado State University. Original ARPA-E funding and raised many millions of public funding
- AtmosZero Boiler 2.0 is an Air-to-Steam IHP
 - Steam to 150°C; Can operate at ambient temperature below 32°C.
 - Designed to be a drop-in replacement for existing boilers, minimizing plant disruption.
 - Multi-stage compression. Utilizes proprietary compressor technology
- First pilot: New Belgium Brewery in Colorado.



York



- A key player in the U.S. HVAC/Chiller market
- Their large chillers can be used as heat pumps, but limited to conventional temperatures (180°F)

JCI/York IHP Product Offerings

- A key player in the U.S. HVAC/Chiller market
- Their large chillers can be used as heat pumps, but limited to conventional temperatures (180°F)

ALL NEW: YORK Low GWP Heat Pump Suite of Offerings



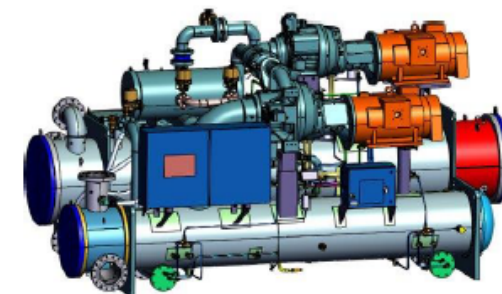
YMAE - 35T Modular, up to 140T

- Produces up to 140°F
- Operates to -10°F
- VSD Scroll + EC fan = 20 IPLV
- 2 – pipe and 4 – pipe configuration
- Pumping Kits Available
- HFO Blend R454B



YVWH – Variable Speed Screw

- Produces 4500MBH of 176°F Hot Water while chilling 200T of cooling load to 44°F
- COP.H at maximum lift = 2.3
- Load reduction to 25%
- HFO R1234ze or HFO blend R515B

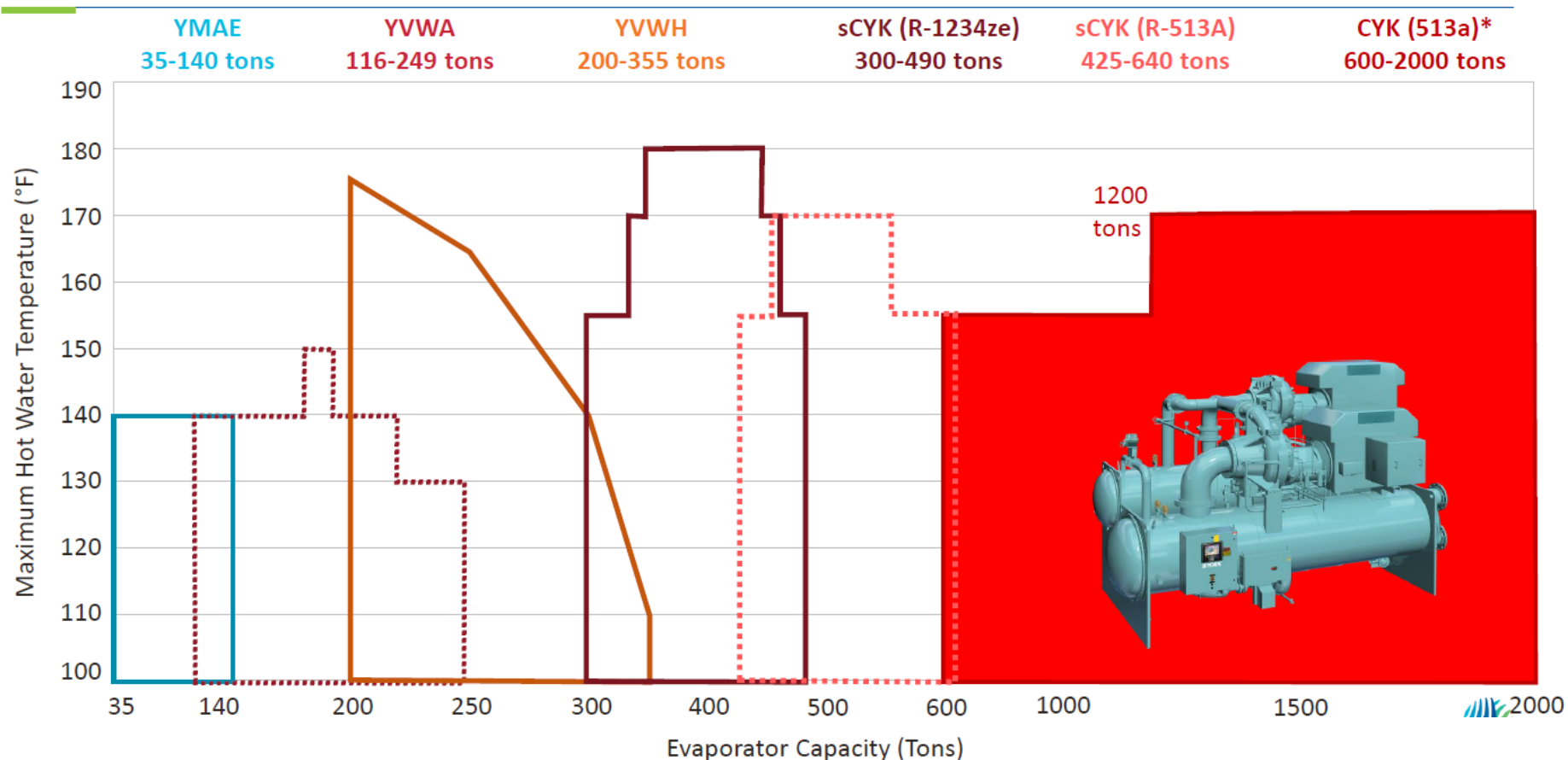


CYK – Compound Centrifugal

- Produces 6500MBH of 180°F Hot Water while chilling 400T of cooling load to 44°F
- COP.H at maximum lift = 2.9
- Load reduction to 40%
- HFO R1234ze or HFO blend R515B

York/JCI product offerings

YORK Heat Pump Offering: Capacity vs Temperature





Industrial Heat Pumps Applications and Installation Configurations

IHP Best Applications

- Best when there is availability of waste heat and needing high temperature water or low temperature steam for internal use majority of the year.
- Ideal for applications needing simultaneous heating (boiler) and cooling (chiller)
- Moderate temperature lift (< 100 F) for higher heat pump efficiency
- Facilities seeking to reduce carbon footprint because of their corporate sustainability goals
 - Ex: European and high-tech companies
- Facilities with relatively low electric prices and higher gas prices. Ratio of electric/gas prices less than 4.
- When the facility accepts longer-term payback time (> 3 years). Facilities that can take value of carbon credits

Barriers to Market



Higher Electric to Gas Price Ratio



Capital Intensive – Higher design and installation costs



Space Constraints for installation



Electrical Power available / Grid capability



Lack of capability – Not available for higher temperature (>230F) applications



Lack of Awareness and Limited Installations in the USA



Industrial Heat Pumps - Installation Configurations

IHP Installation

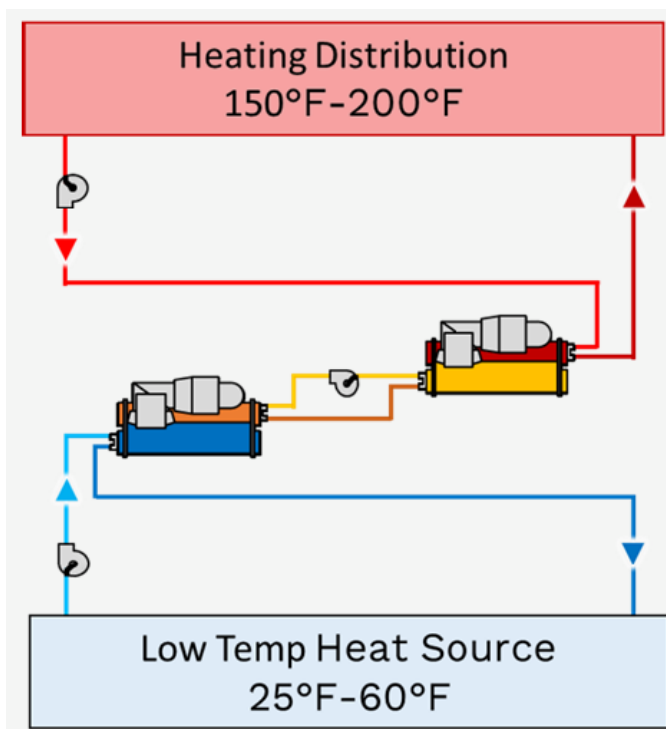
Configuration #1: Heat Recovery Heat Pump



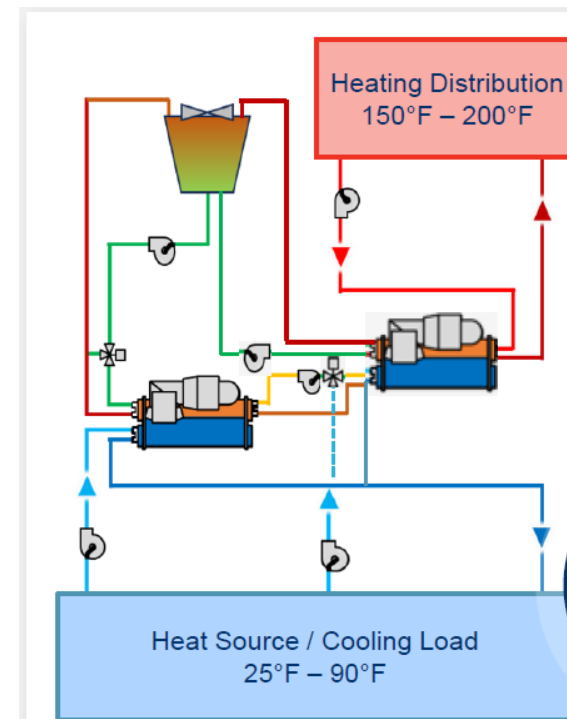
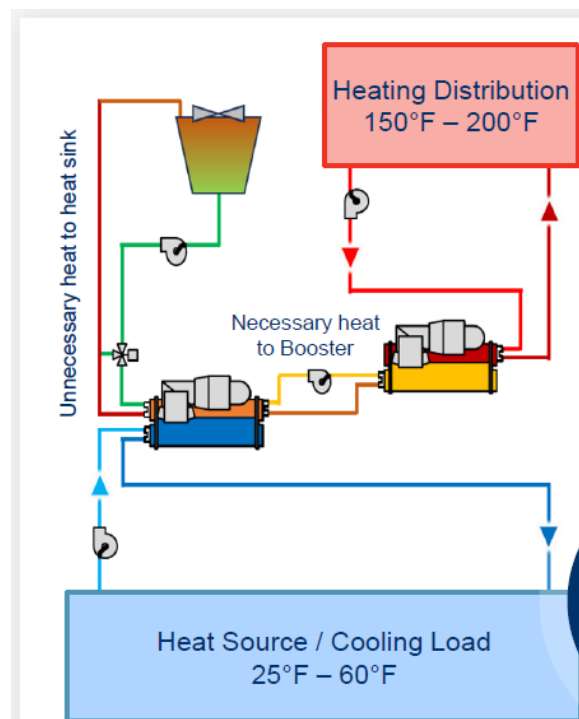
- **Technology:** Combined heating and cooling (simultaneous production of chiller water and hot water)
- **Ideal application for:**
 - Simultaneous needs for chilled water (chiller) and higher temperature hot water (boiler) majority of the year
 - Moderate temperature lift (<100 F) for higher heat pump efficiency
 - Higher COP: >5.0
- **Best Applications:**
 - Commercial Segment: Large hospitals, large high-rise hotels, large high-rise office buildings, university campus, district heating and cooling, airports
 - Manufacturing: Food and Beverage, meat and poultry processing, Dairies, automotive, textiles, and others

Heat Recovery Heat Pump Configurations

- System configuration for heating distribution shown below



Source: Trane

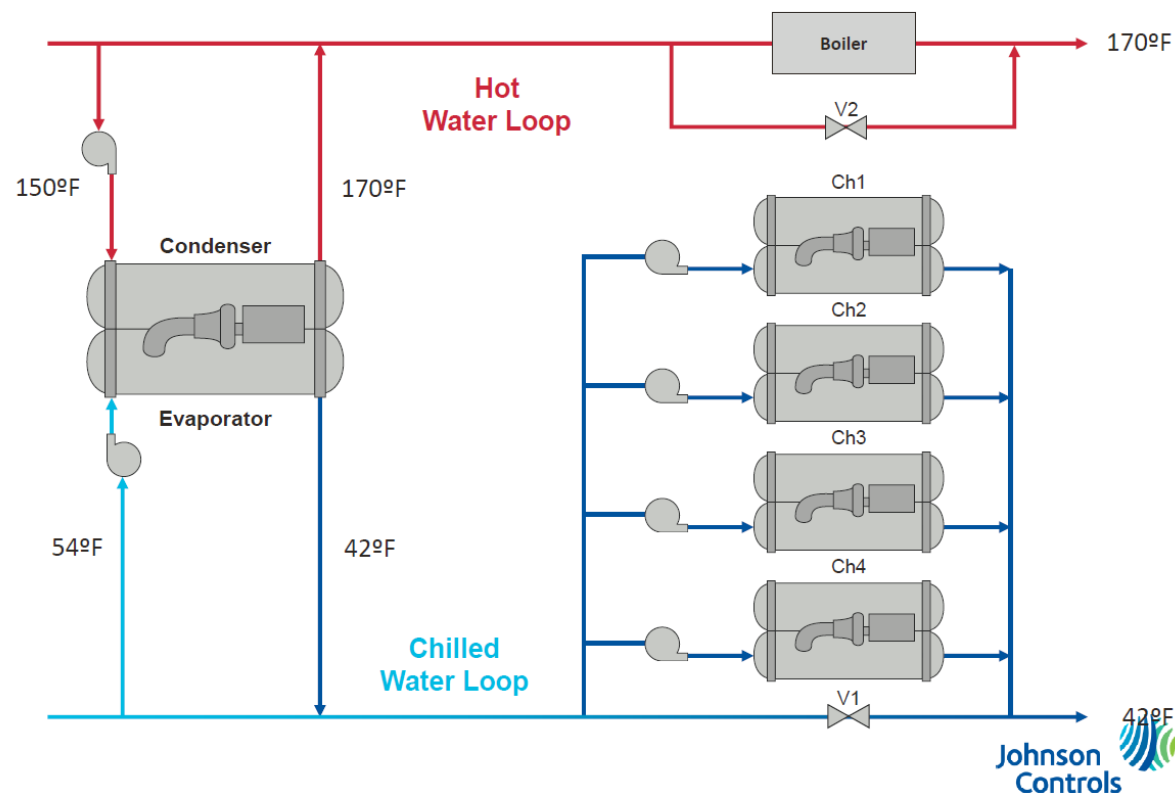


Heat Recovery Heat Pump System Configuration

Heat Pump System Configurations

Typical “Side-Car” Configuration

Run the heat pump chiller as much as possible to maximize system energy savings

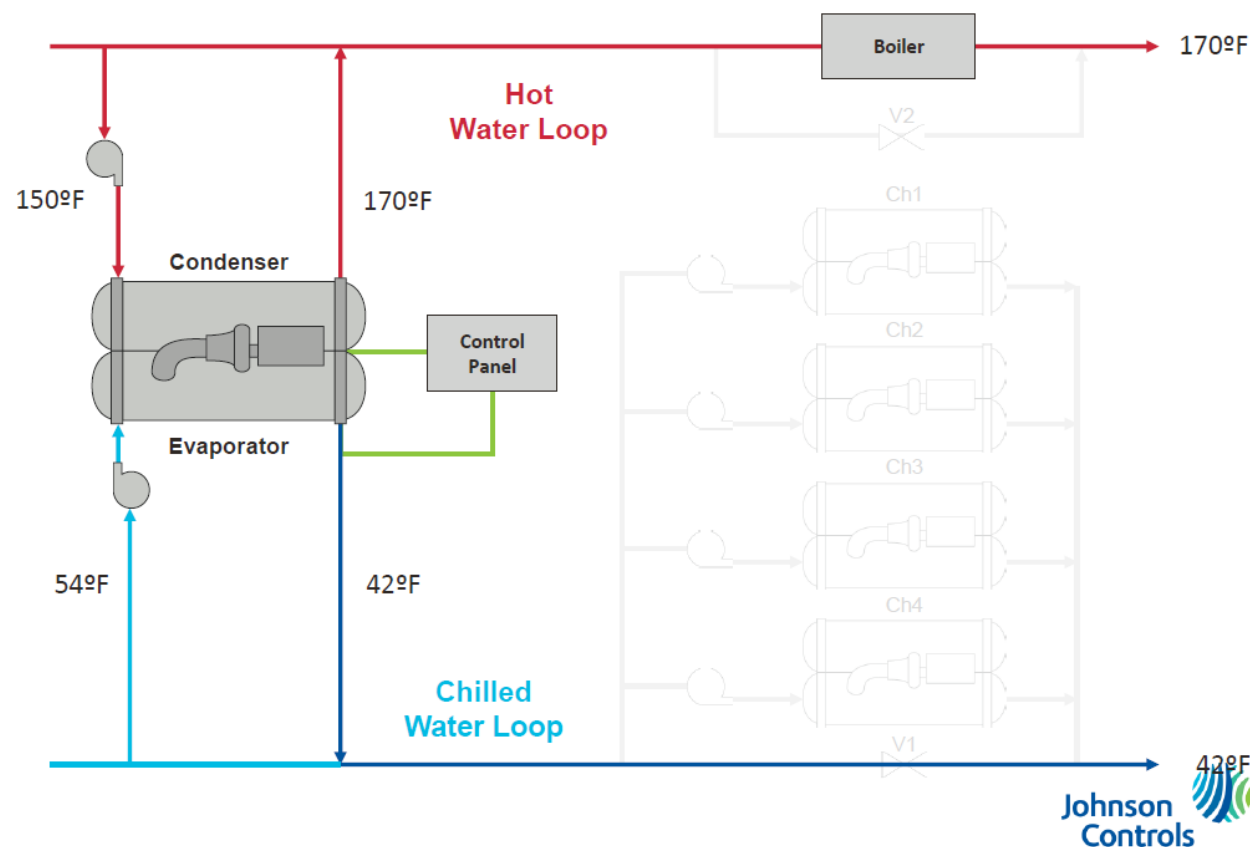


Heat Recovery Heat Pump System Operation

Heat Pump Control – Winter Mode

Typical “Side-Car”
Configuration

Heating load dominant
(cooling control)

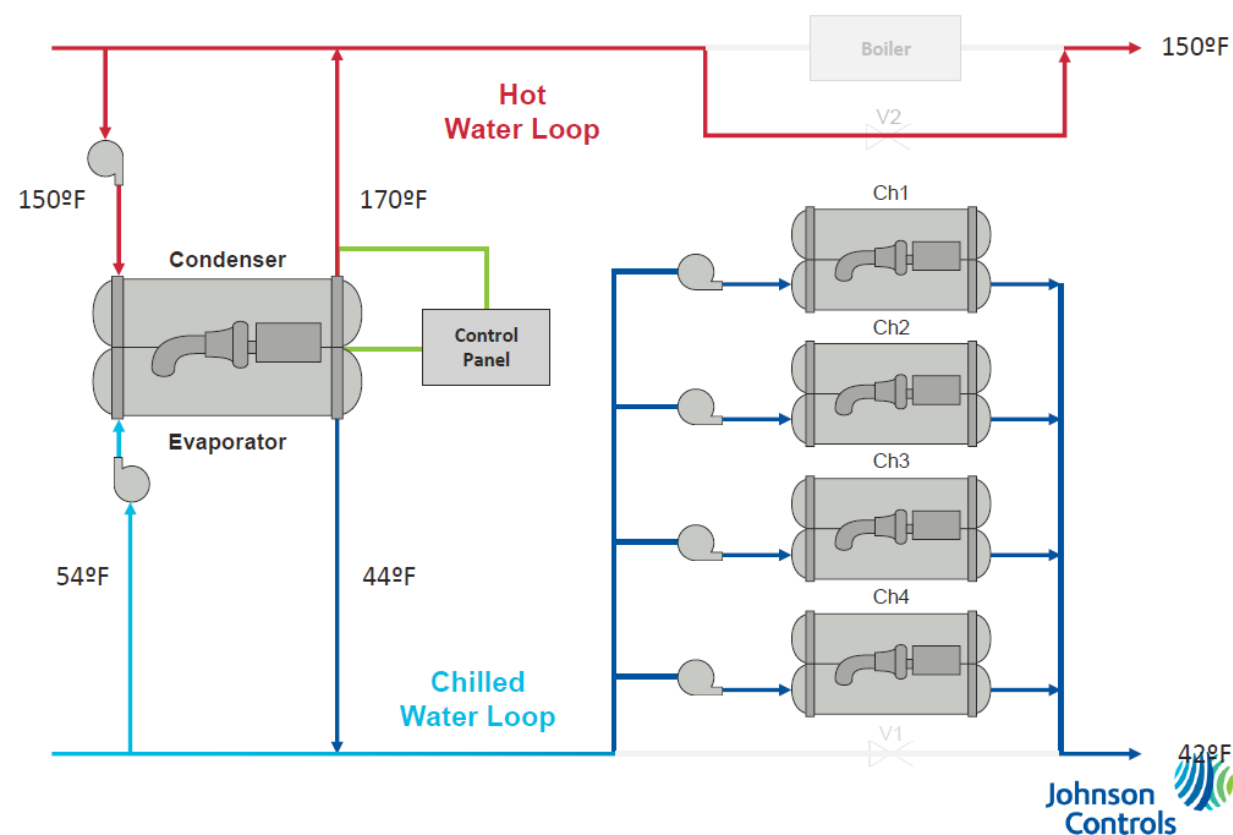
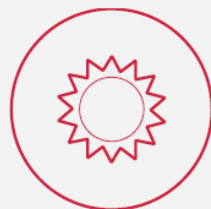


Heat Recovery Heat Pump Operation

Heat Pump Control – Summer Mode

Typical “Side-Car” Configuration

Cooling load dominant
(heating control)



IHP Installation

Configuration #2: Waste Heat Recovery HP

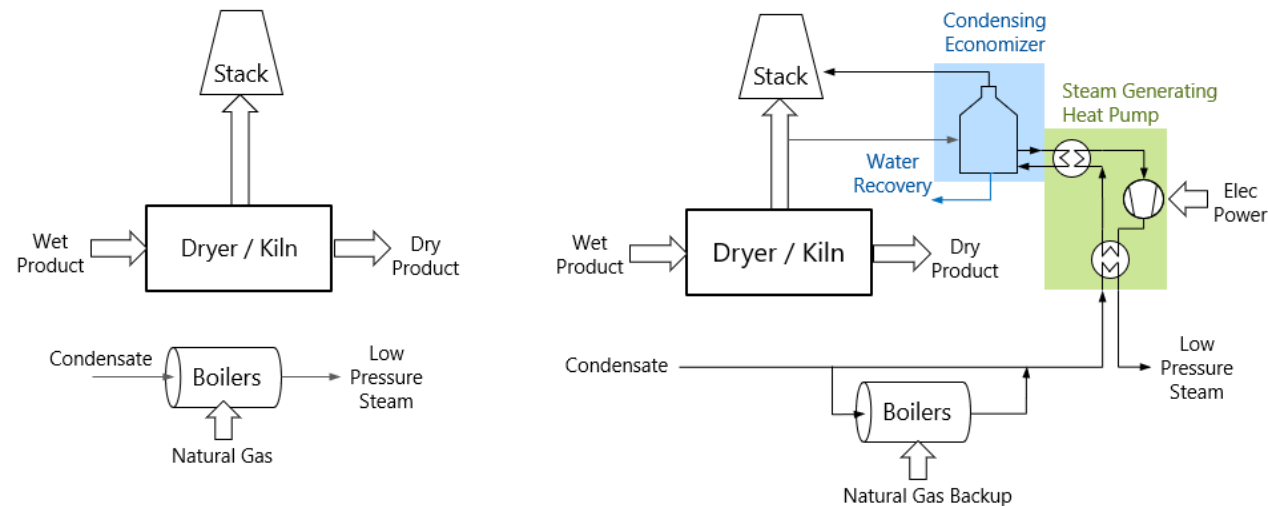


- **Technology:**
 - Conventional heat pump technology lifting low-grade waste heat to higher-grade useful heat
- **Ideal application for:**
 - Simultaneous availability of low-grade waste heat and needs of higher temperature hot water or steam for internal process needs for majority of the year
 - Moderate temperature lift (<100 F) for higher heat pump efficiency. But IHP technologies are available for higher lift (>100 F) but utilize multi-stage compression
- **Best Applications:**
 - Manufacturing: Food and Beverage, chemical, pulp and paper, metal fabrication, textiles, and many others

Waste heat for low pressure steam: Materials Industry

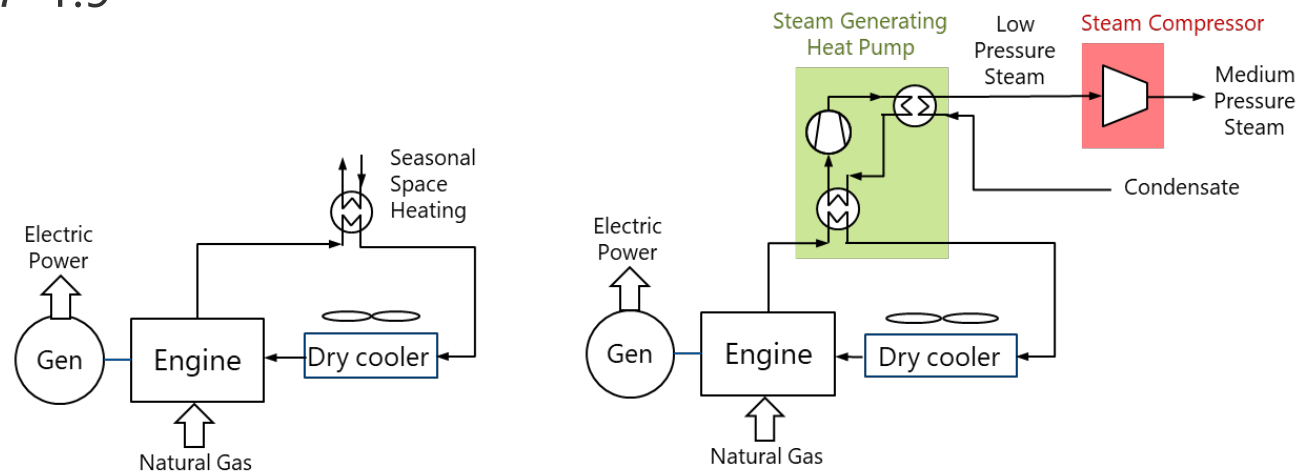
Low Pressure Steam Generation from Dryer Exhaust

- Add condensing economizer to capture waste heat and recover water
- Utilize steam-generating heat pump for drying.
- COP of 3.7-4.3



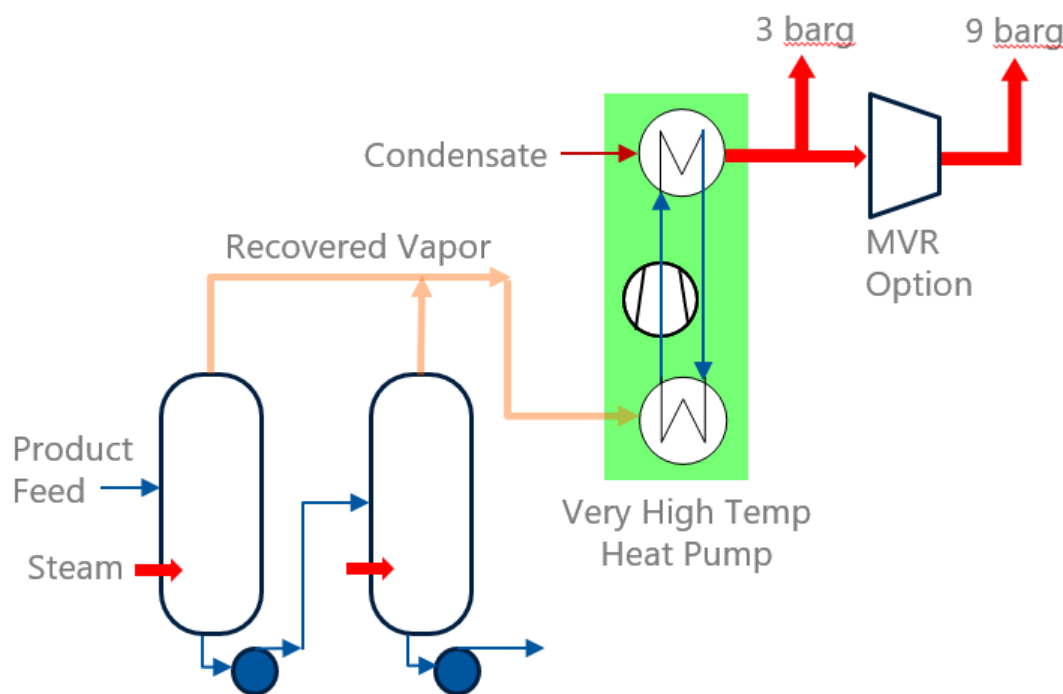
Waste heat for medium pressure steam: Food production

- Medium Pressure Steam Generation from CHP Cooling System
- Steam used in plant processes
- COP = 1.7-1.9



Waste heat to steam: Chemical Plant

- Recovered vapor (subatmospheric) used as heat source
- Low pressure Steam generation (3 bar) in combination with MVR (9 bar)



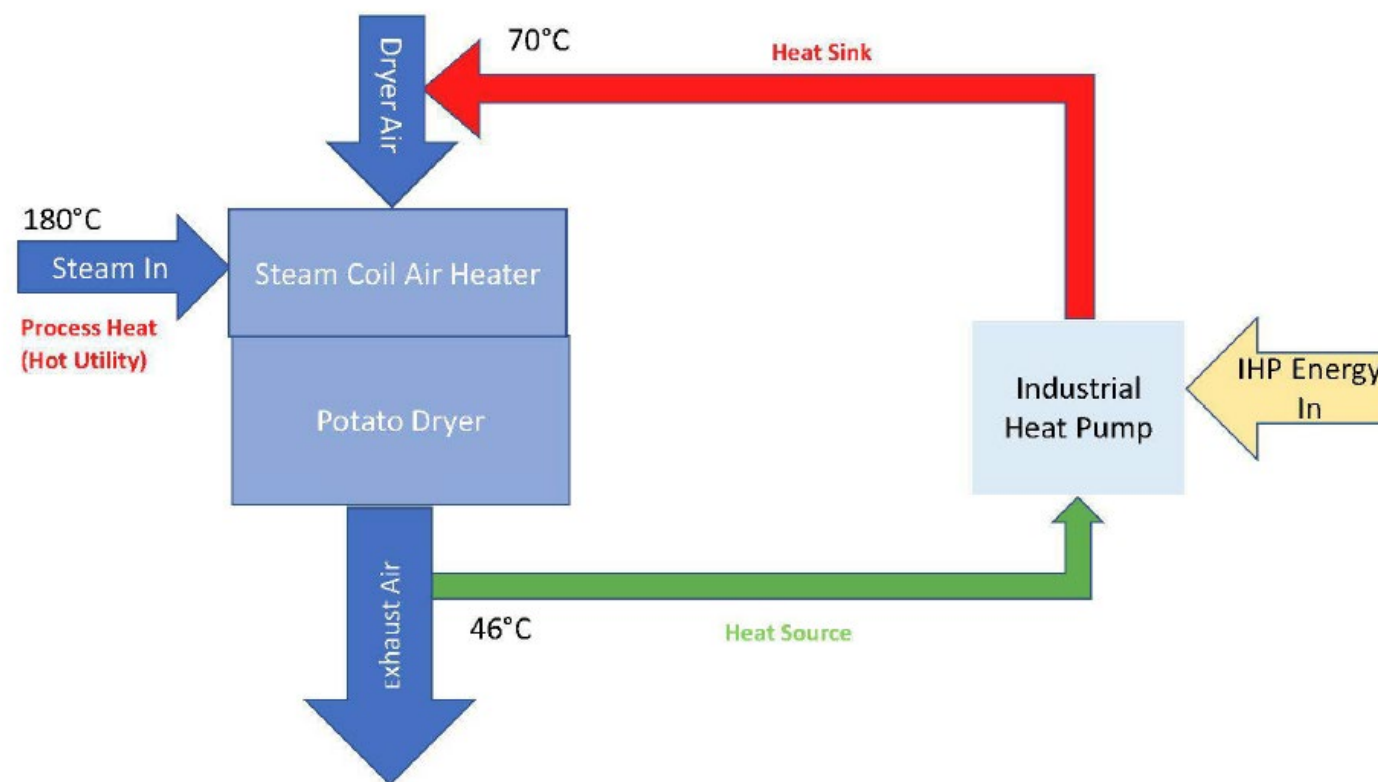
Waste heat to low pressure steam: Food Production

- Installed 2023 in the Netherlands
- Heat source: CHP cooling jacket water
- Heat sink: 2 barg steam
- Capacity: 514 kW
- COP = 4.4



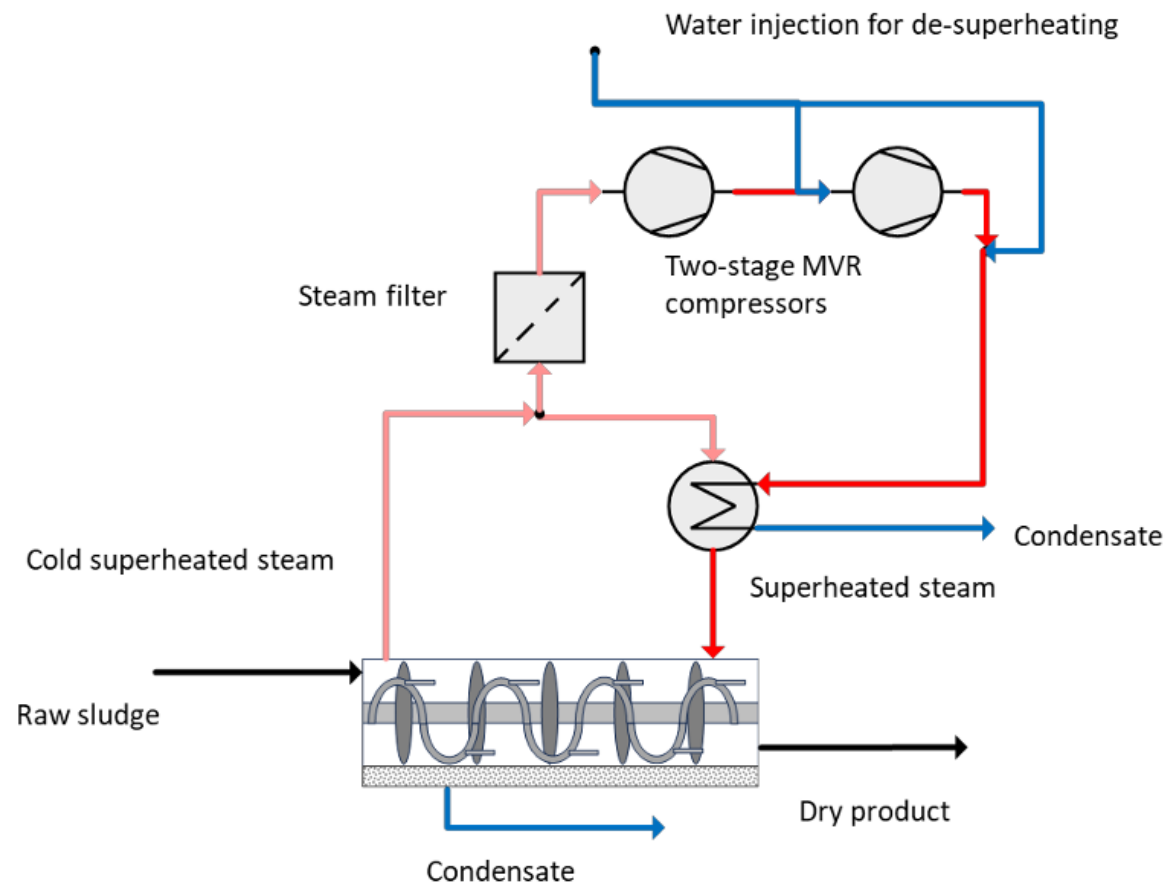
Waste Heat for Potato Drying

- Possible IHP in potato drying
- COP = 2.4 - 5.1



Sludge Drying Application – Waste Water Treatment

- Concept tested in Norway
- Steam at 120°C
- COP = 4.5



Steam Generating Heat Pump - Hospital

- Heat source could be cooling tower water
- Low pressure steam generated by heat pump
- Steam boosted to medium pressure by steam compressor
- COP depends on source/sink temperatures

