IDEA2021

Powering the Future: District Energy/CHP/Microgrids

Sept. 27-29 | Austin Convention Center | Austin, Texas

The Art of Heat Pump Chillers

Rajesh Dixit, Director – Global Product Management
Johnson Controls

Expressing the Art of Heat Pump

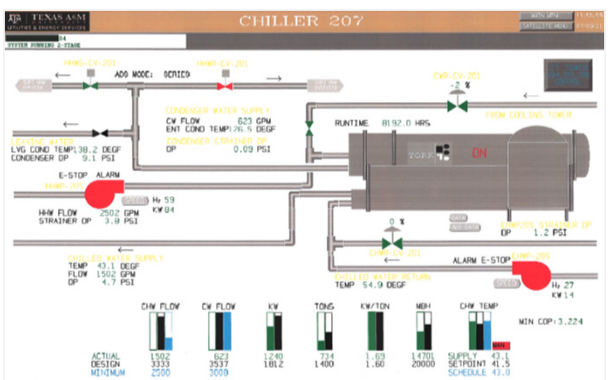
- Introduction
- University Campus Simultaneous Cooling and Heating
- Sewage Waste Heat Recovery
- Ultra-Low GWP District Heating
- Zero GWP District Heating
- Recap – Moving Toward a Sustainable Future

Texas A&M

Rajesh Dixit – Director, Global Product Management

Johnson Controls

Great Operational Flexibility – Texas A&M Lab
Additional Cooling Capacity w/o Adding Cooling Towers



Simultaneous cooling and heating

Makes very cold or very hot water as desired by the lab

Heat pump chiller provides chilled water without adding cooling towers and also provides heating water!

Chilled Water
54/42°F
(12/5.5°C)

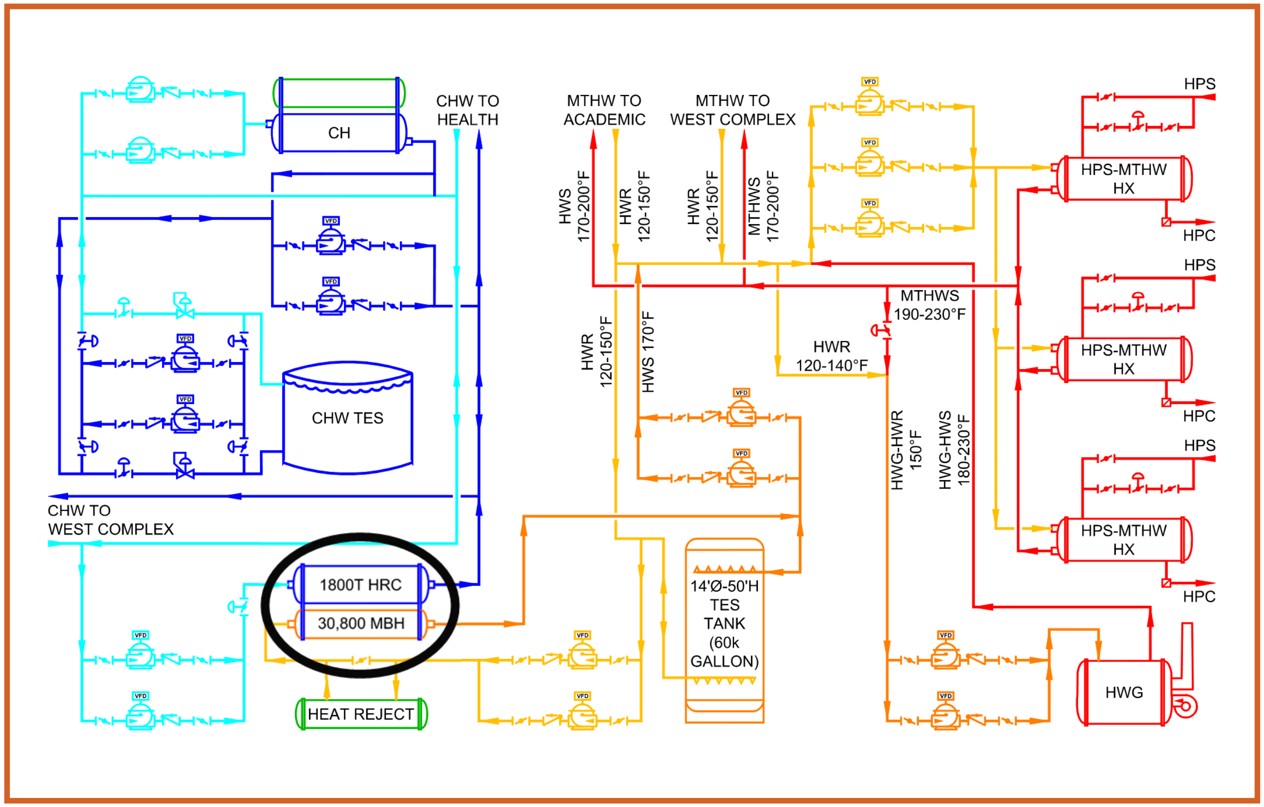
Heating Water
135/155°F
(57/68°C)

Heating COP
3.2, Combined
COP 5.5

University of Virginia

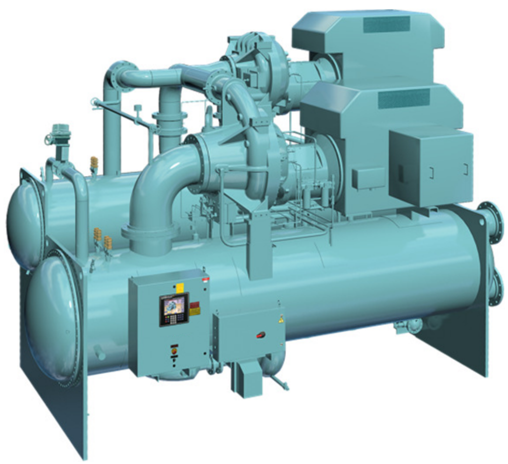
Paul Zmick, E&U Director

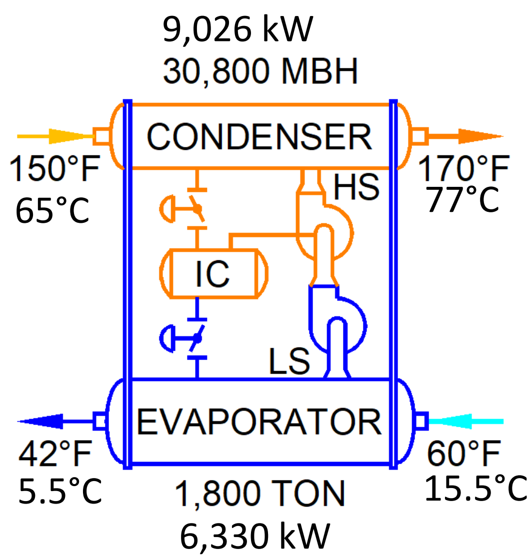
Simultaneous Cooling (42°F/5.5°C) and Heating Water (as High as 170°F/77°C)

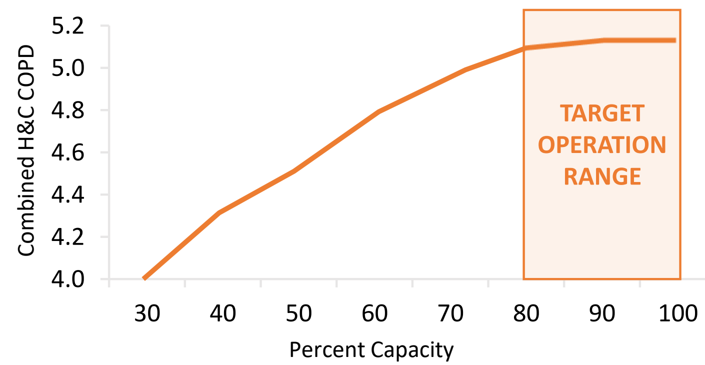


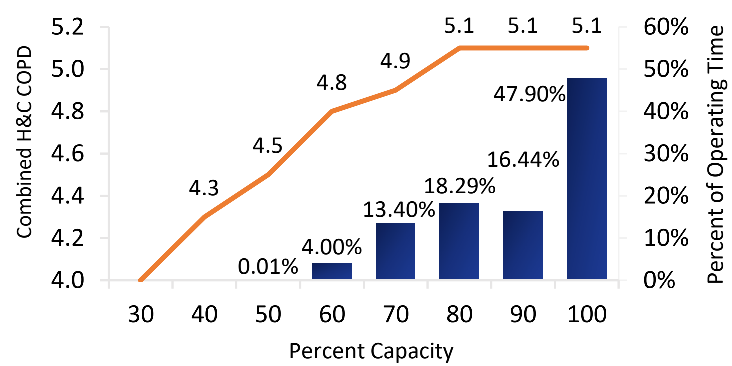
- Conversion from medium pressure steam and high temperature hot water to low temperature hot water
- Retrofit existing buildings, 170°F (77°C) heating water critical
- Simultaneous cooling and heating
- Heat recovery chiller (HRC) Base loaded
- Boilers and other chillers supplement the HRC, as needed
- Hot water storage tank (for turndown) and dump radiator

Heat Recovery Chiller COP 5.12 (7x More Efficient than Steam Plant) High Capacity High Temperature High Lift

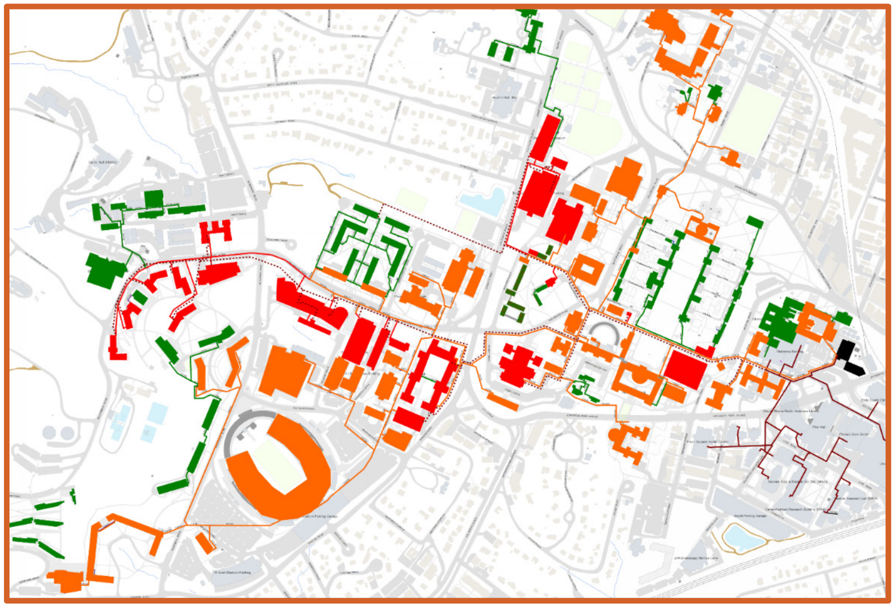








Design Optimization by Manufacturer Enables Huge Flow Fluctuation – Summer and Winter



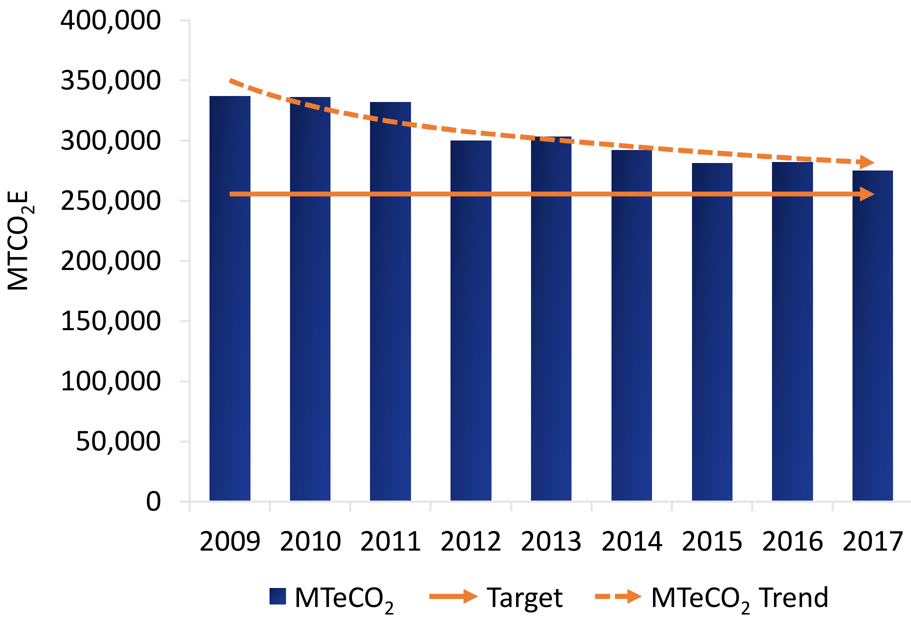
Legend

- MPS Building Conversion
- MTHW Building Conversion
- LTHW Building Conversion
- De-activated MPS
- Existing MPS
- New LTHW
- Convert MTHW to LTHW
- Existing LTHW
- New MTHW
- Existing MTHW

Parameter	Summer	Winter
Efficiency (kW/ton)	1.764	1.786
Capacity	1500 Tons (5,275 kW)	1800 Tons (6,330 kW)
Evaporator	1,562 gpm (359 m³/h) (65/42°F) (18/5.5°C)	**6,617 gpm** **(1,522 m³/h)** (48.5/42°F) (9.1/5.5°C)
Condenser	1,753 gpm (403 m³/h) (140/170°F) (60/76.6°C)	**4,030 gpm** **(927 m³/h)** (154/170°F) (67.7/76.6°C)

Heat Recovery Chiller Supports UVA's Climate Action Goal Carbon Neutrality by 2030, Fossil Fuel Free by 2050

UVA's goal is to reduce GHG emissions 25% below 2009 levels by 2025



12,000 metric tonnes of CO_2 emissions to be avoided annually due to the heat recovery chiller

City of Vancouver False Creek Neighborhood Energy Utility

Ayman Fahmy, Team Lead – District Energy
Kerr Wood Leidal

False Creek Energy Center
Innovative Neighborhood Energy Utility

1st Renewable district heating system in Vancouver Canada

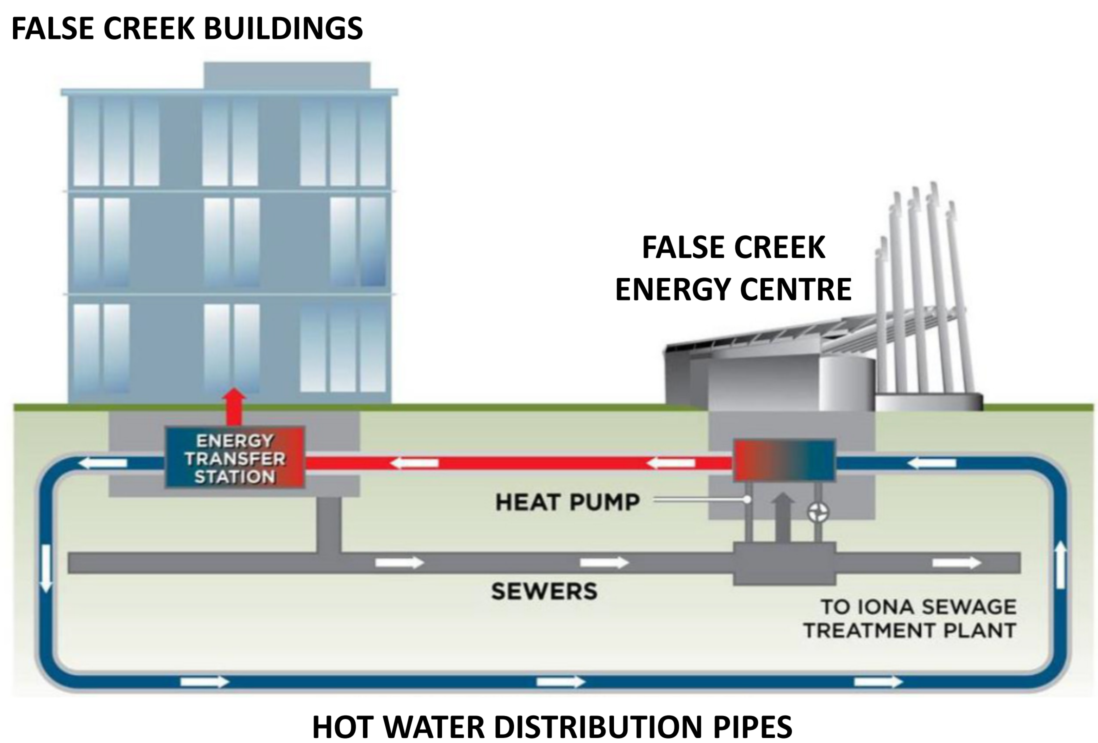
Started in 2010; currently serving **6 million ft²** (0.5 million m²); expanding to **23 million ft²** (2 million m²)

1st Large scale waste-water heat pump system in North America

70% of heat generated using renewable energy; 100% by 2030

Sewage Heat Recovery Heat Pump – Low Carbon Technology

- Recovered waste heat from screened municipal sewage
- Heat water from heat pumps and boilers to service buildings in the neighborhood
- Distribution pipes buried under the streets
- Each building with its own energy transfer station



Important Considerations

Original (2008) design considered 3.0 MW in the 1st phase and an additional 3.0 MW in the 2nd phase

Maximizing performance with space constraints

Limit motor size to 1000 KW (avoiding 24x7 operator)

Evaporator tube material CuNi 90:10 (sewage water)

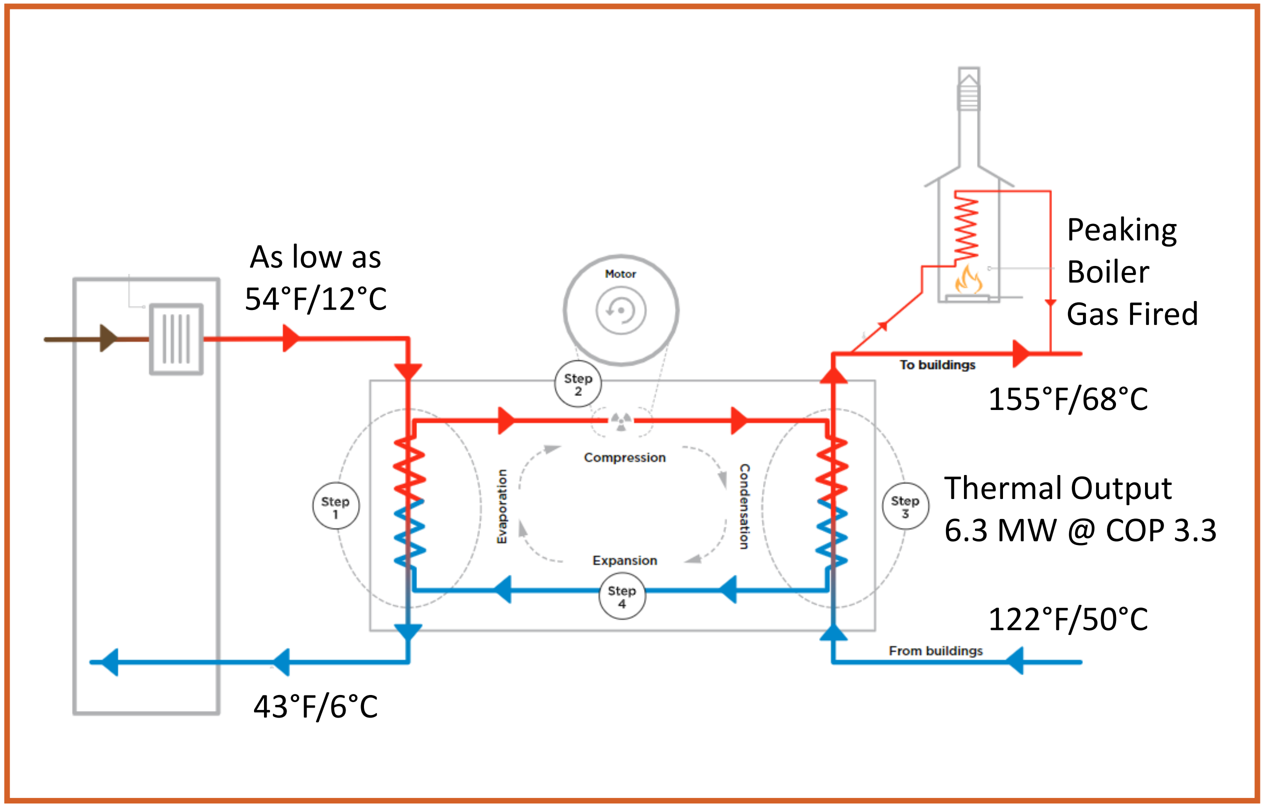
Close collaboration with the heat pump manufacturer resulted in optimizing the design to get up to 6.3 MW (21,500 MBH) instead of the 3.0 MW (10,236 MBH) expansion originally intended

Variable sewage conditions

Low GWP refrigerant (R-513A) required by the city

Factory Test – For performance validation

New 6.3 MW Centrifugal Heat Pumps to Supplement Existing 3.0 MW Screw Heat Pumps



Fully packaged high temperature high lift centrifugal heat pumps will provide **155°F/68°C heating water** (21,500 MBH/6.3 MW) for connected buildings

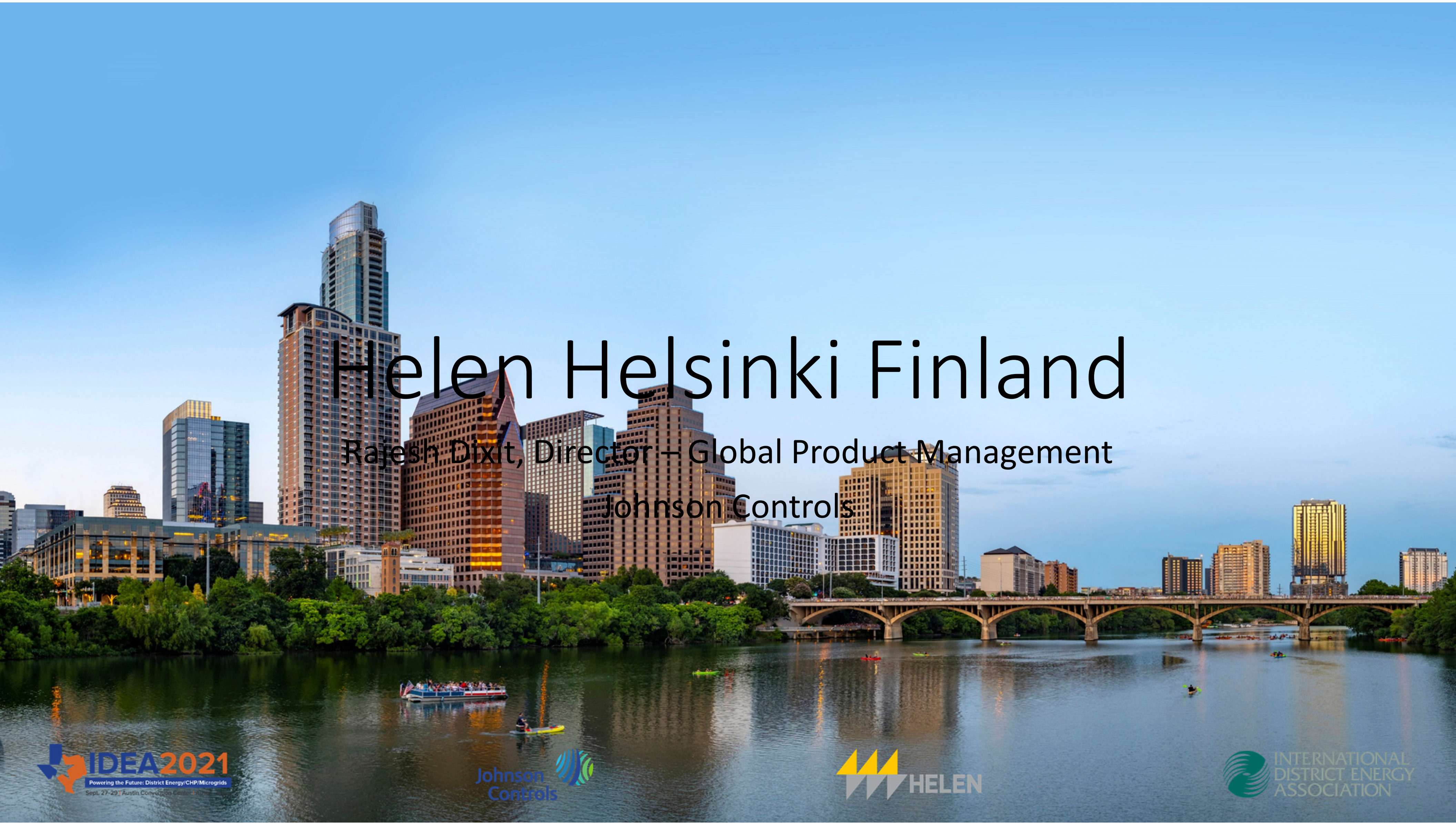
Gas boilers (82,000 MBH/24 MW) are for supplemental heating during coldest days of the year

System commissioning in 2022

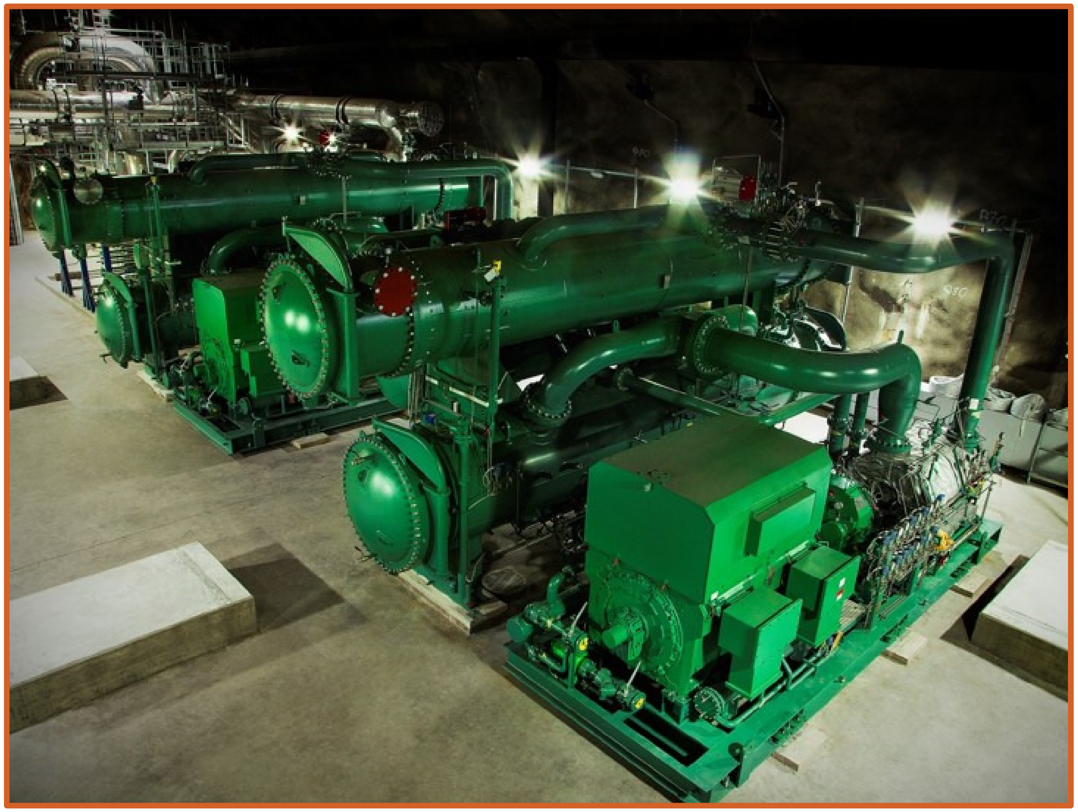
Helen Helsinki Finland

Rajesh Dixit, Director – Global Product Management

Johnson Controls



Renewable Urban Energy by Helen in Helsinki Keskuskatu District Energy Station



Helen's investment in two massive centrifugal heat pumps in 2018, resulting in less usage of fossil fuel (coal) and cutting CO_2 emissions by 20,000 tons per year

Underground cooling center (excavated cave) at a depth of 164 ft (50 m)

Extending the district cooling capacity in Keskuskatu from 9,971 (35 MW) Tons to 14,245 Tons (50 MW)

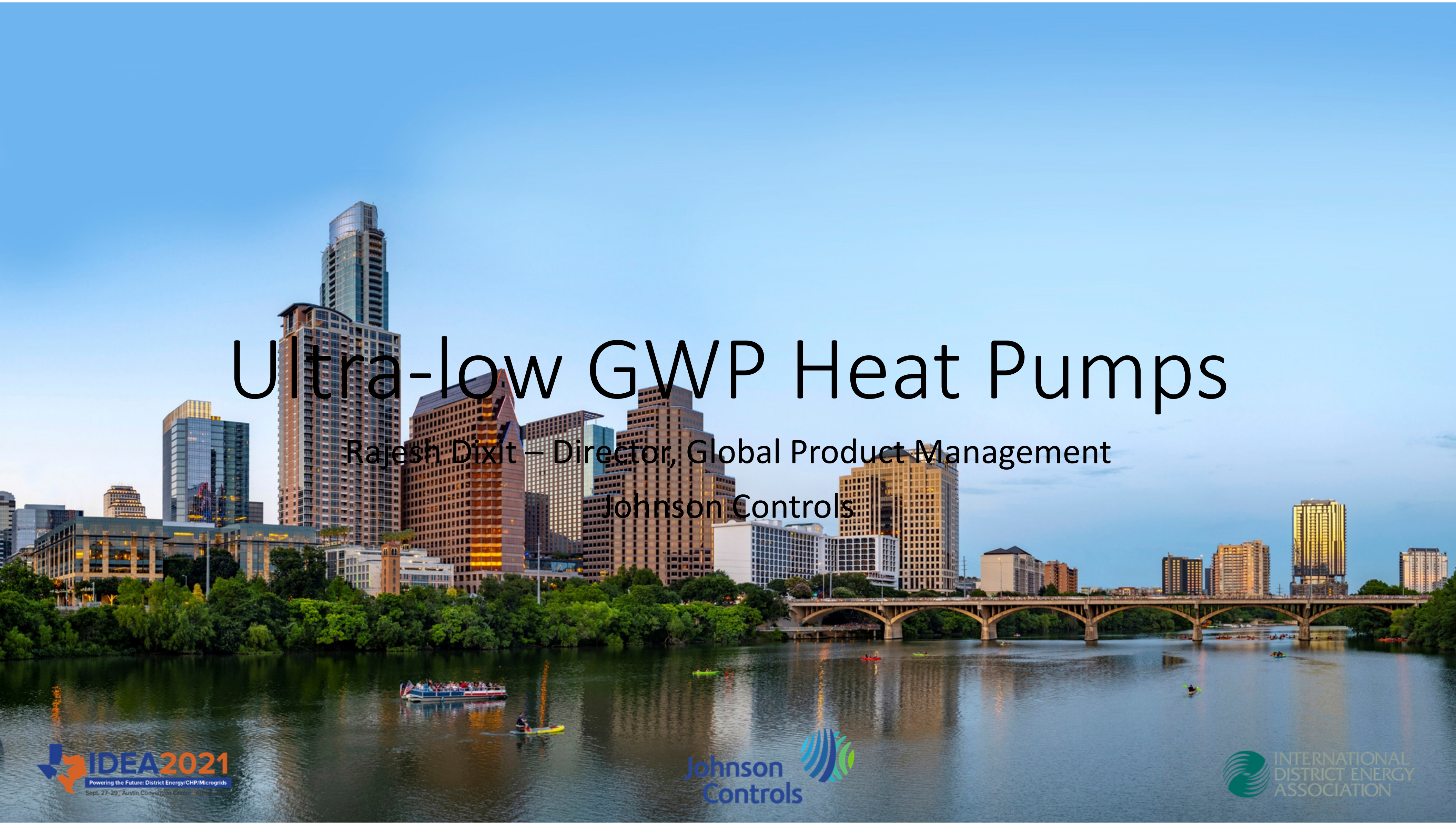
Delivering district heating capacity 75,067 MBH (22 MW), equivalent to 10,000 apartment buildings

Combined COP 5.63, Chilled Water 37.4°F (3°C), Heating Water 176°F (80°C)

Ultra-low GWP Heat Pumps

Rajesh Dixit – Director, Global Product Management

Johnson Controls



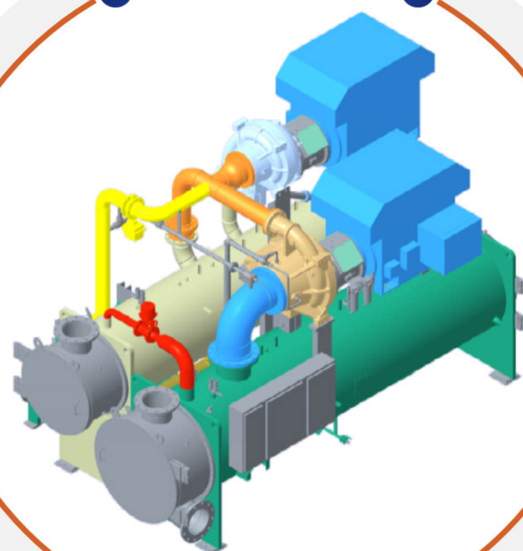
Ultra-low GWP Compound Centrifugal Heat Pump Delivers Very High District Heating Water 185°F (85°C)

Western Europe

2 Units in Series Counter-flow

15 MW (51,182 MBH)
District Heating

Ultra-low GWP Refrigerant
(R-1234ze)



Variable Speed Drive
for better Turndown

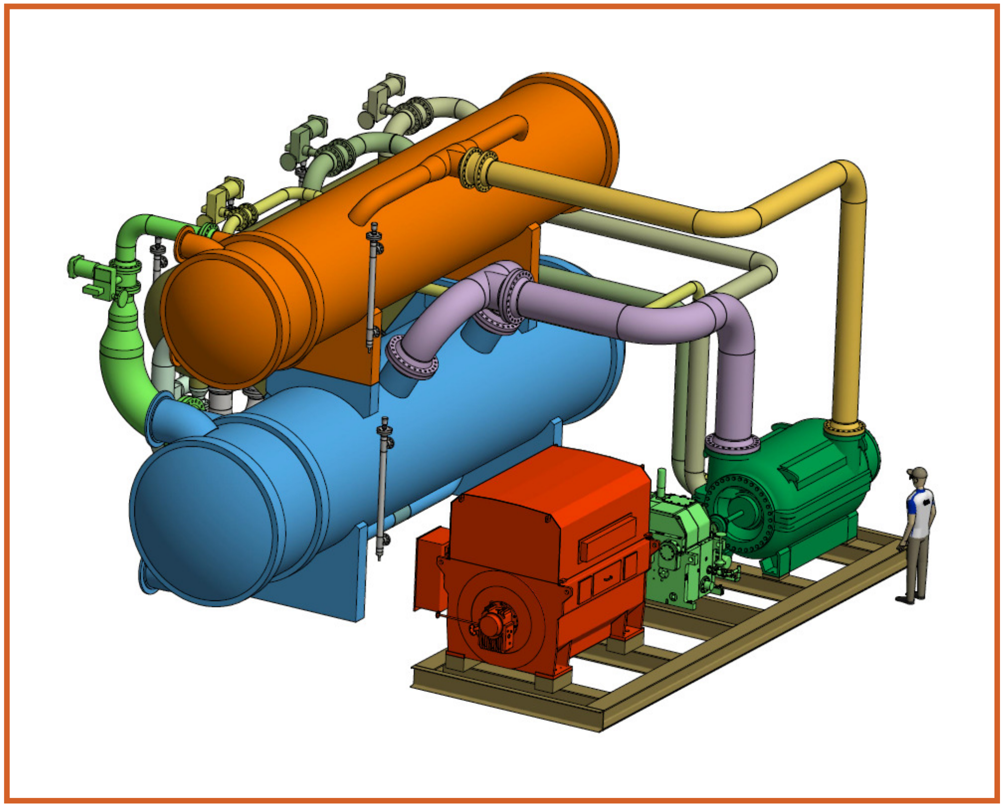
Evaporator (River Water)
73/41°F (23/5°C)

Heating Water
144/185°F (62/85°C)

Heating COP 3.0

Ultra-low GWP Multi-stage Centrifugal Heat Pump Delivers Very High District Heating Water 199°F (93°C)

- Central Europe
- Three Multi-stage Centrifugal Heat Pumps
- 60 MW (204,782 MBH) District Heating
- Ultra-low GWP Refrigerant (R-1234ze)
- Sewage Heat Recovery 59/50°F (15/10°C)
- Heating Water 140/199°F (60/93°C)
- Heating COP 3.8



ZERO GWP Ammonia Heat Pumps

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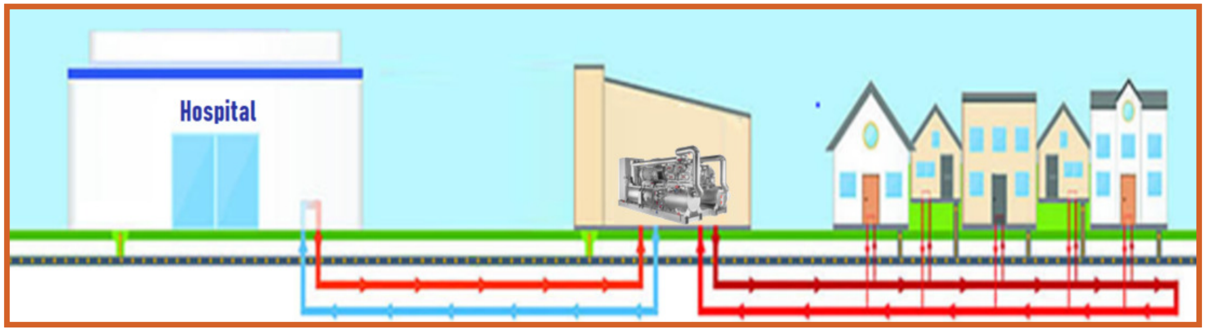
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Ammonia (R717) Heat Pumps – Zero GWP Highly Efficient Solution Cooling the Hospitals in Denmark, Providing Heat to Other Buildings



Simultaneously cooling the hospitals (1707 Tons, 5992 kW) and providing district heating (26614 MBH, 7800 kW) for other buildings

Chilled Water
Return 64.4°F/18°C, Supply 53.6°F/12°C

Heating Water
Return 86°F/30°C, Supply 167°F/75°C

Solution
4x 2-stage heat pumps (reciprocating & screw)

Heating COP
4.1, Cooling and Heating COP: 7.3

Ammonia (R717) Heat Pumps – Zero GWP Highly Efficient Solution
Flue Gas Waste Heat Recovery to District Heating
Provides 20% of the total district heating production, Cuts CO_2 2,000 tons / year

Manufacturing of protein feed for animals results in hot air at (194°F, 90°C)

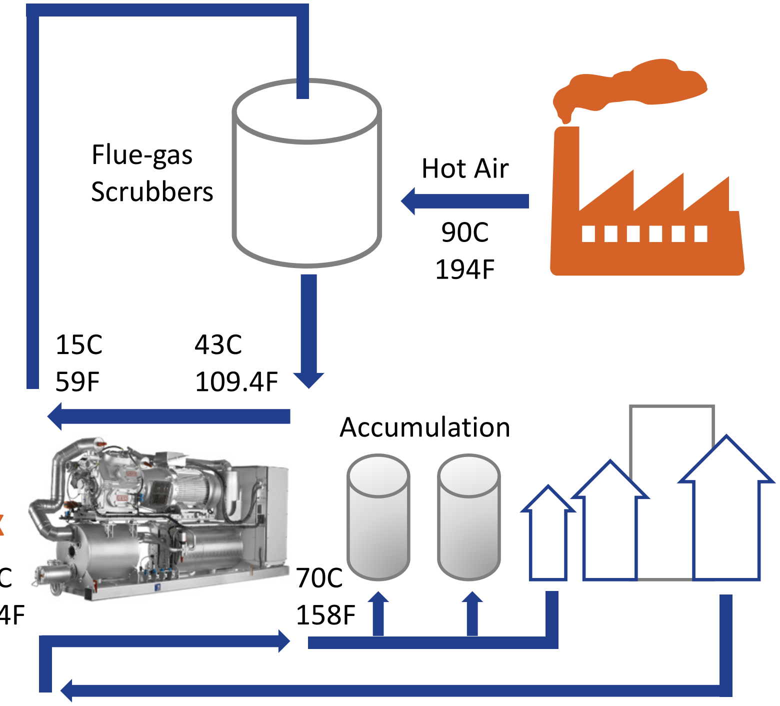
The hot air is cooled in the scrubber by the chilled water, condenser provides district heating water

Chilled Water (2,862 Tons / 10,047 kW)
Return 109.4°F/43°C, Supply 59°F/15°C

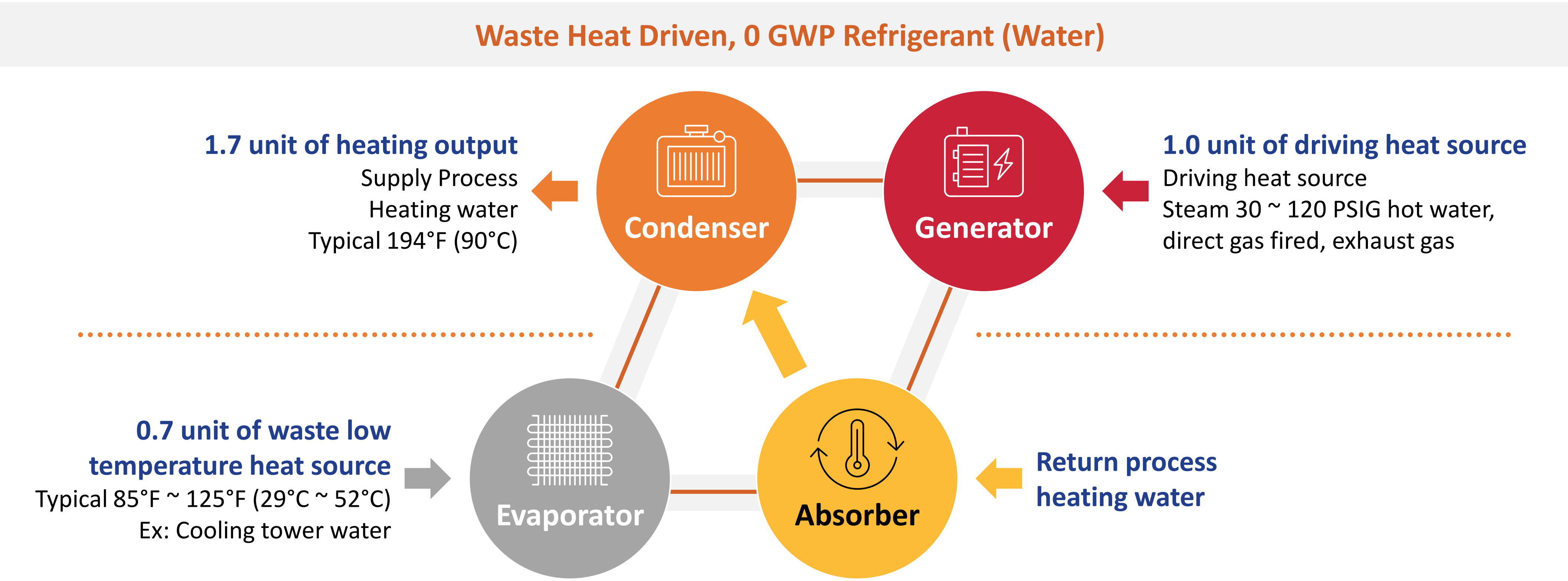
Heating Water (41,131 MBH / 12,113 kW)
Return 104°F/40°C, Supply 158°F/70°C

Reciprocating heat pumps operating in series

Heating COP
5.6, Cooling and Heating COP: 10.2

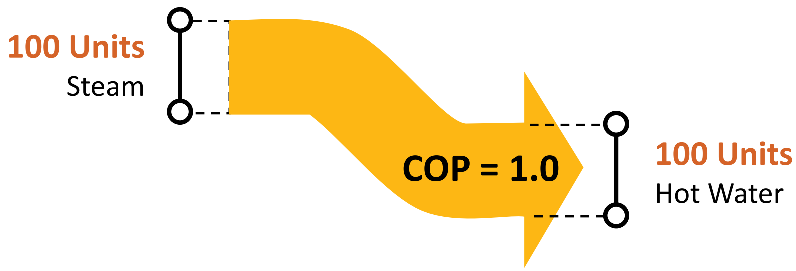


Waste Heat Driven Absorption Heat Pump, 0 GWP
A Truly Sustainable Technology

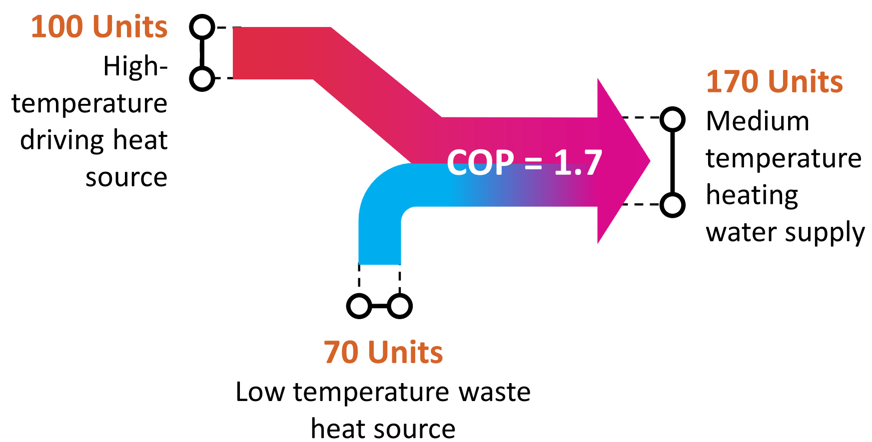


Quick Payback Compared to a Boiler

Steam from Boiler



Absorption Heat Pump (Heat Amplification)

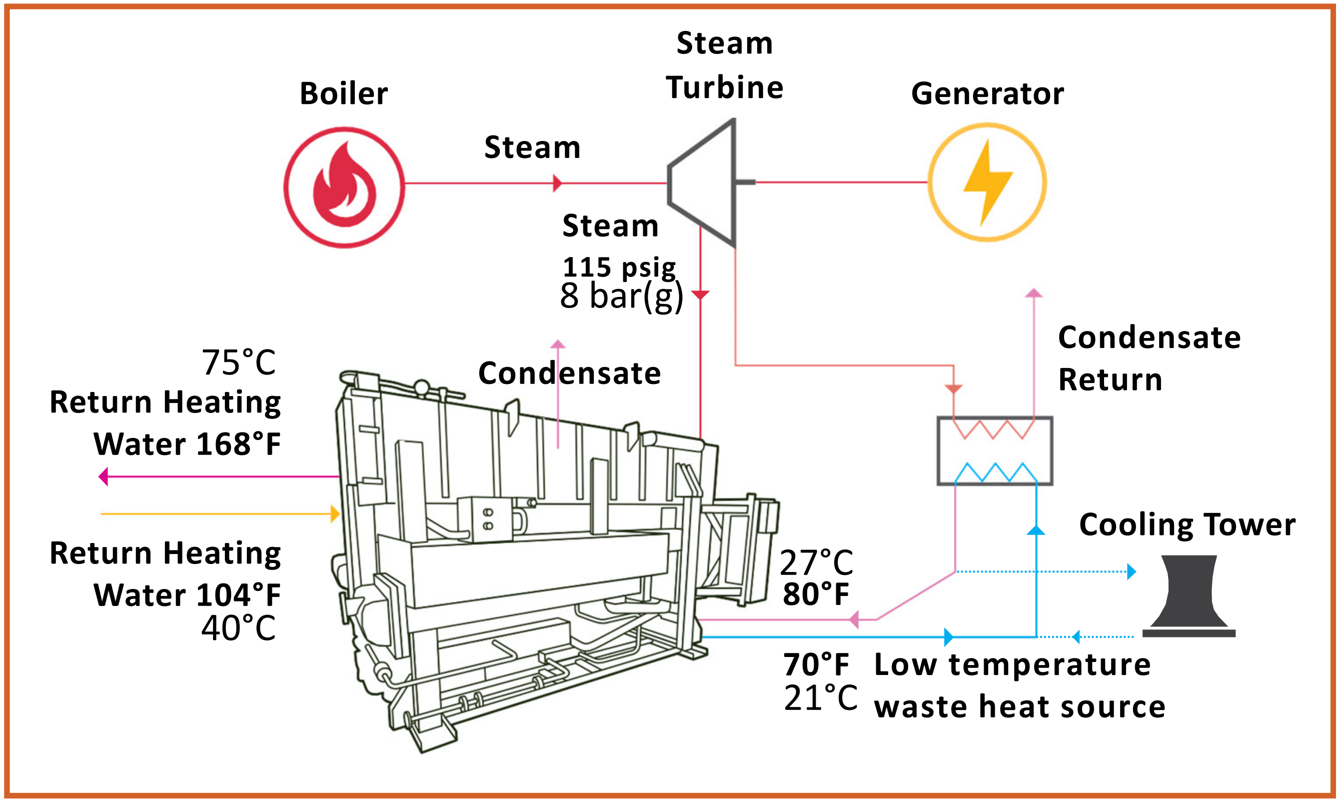


Steam Driven, Zero GWP, Absorption Heat Pump Application

Extracted Steam
Driving Heat Source

Evaporator Waste Heat
Cooling Tower Water

Heating Water 168°F for
Boiler Feed Water Heating



Towards A Sustainable Future
Every Chiller is a Heat Pump

Moving the BTUs efficiently

Proven renewable technology

Tailor-made for your application

A key technology to achieve your sustainability goals

Diversity of Usage

Industrial Waste Heat Recovery, University Campus Cooling and Heating, District Heating

Diversity of Refrigerants

Low GWP to Ultra-low GWP to Zero GWP

Diversity of Technology

Reciprocating to Screw to Centrifugal to Absorption

Thank You!

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KERR WOOD LEIDAL
consulting engineers