IDEA2019

The Energy for More Resilient Cities

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The New Old Chiller

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Johnson Controls

Acknowledgements

- Hitachi-Johnson Controls A/C Japan

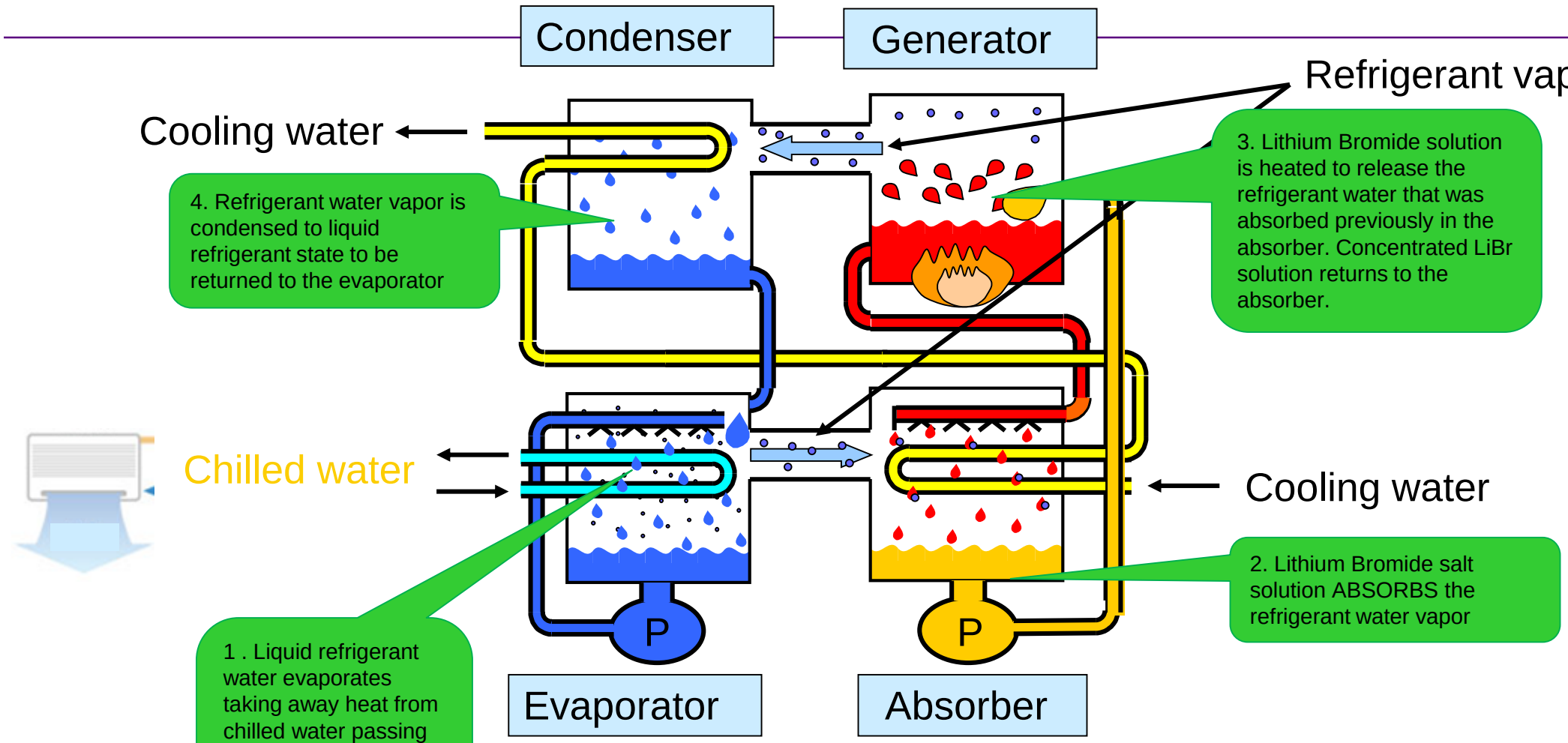
Learning Objectives

- Understand the advances in absorption cooling/heating technology
- Explore new possibilities to deliver resilient and clean cooling/heating

Outline

- Absorption Cooling Technology Overview
- Cost Efficiency, Flexible Operation, Enhanced Reliability
- Innovations
- Recap

How it Works?


Condenser
Generator
Refrigerant vapor
Cooling water
4. Refrigerant water vapor is condensed to liquid refrigerant state to be returned to the evaporator
3. Lithium Bromide solution is heated to release the refrigerant water that was absorbed previously in the absorber. Concentrated LiBr solution returns to the absorber.
Chilled water
Cooling water
2. Lithium Bromide salt solution ABSORBS the refrigerant water vapor
P
P
1 . Liquid refrigerant water evaporates taking away heat from chilled water passing through the tubes. Liquid refrigerant turns into refrigerant water vapor.
Evaporator
Absorber

Absorption Cooling Technology Overview

- Sustainability – Truly Green Solution
  - Water as the refrigerant, Lithium Bromide salt solution as the absorbent
  - Driven by waste heat
    - Steam, hot water, exhaust gas
    - Low cost natural gas/light oil
  - Helps reduce electric and water costs, reduced emissions
- Reliability
  - Around for last 75 years
  - Continued advancements in technology
  - Improves resiliency by not reliant on the congested electric grid
- Suitable for variety of applications
  - Commercial, industrial, marine, CHP, district cooling heating applications

Absorption Chillers are Cost Efficient

1. Typical Chiller COPs Assumed

Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
6.5	1.2	1.4	0.7

2. Natural Gas $ 5/MMBTU, Electricity $ 0.15/kWh, Steam $4 per 1,000 lb (450 Kg)

3. Ton-hour Operational Costs (US cents/ton-hour)

Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
8.12	5.00	3.43	6.86

MMBTU = 1,000,000 Btu

Absorption Chillers Provide Flexible Operation

- Chilled water leaving as low as 23°F (-5°C) with Water-LiBr cycle
- Cooling (condenser) water temperature range 68°F (20°C) ~ 98.6°F (37°C)
- Excellent turndown 100% ~ 10%
- Flow rate variation 5% per minute or 50% of design over 10 minutes
- Flow rate flexibility

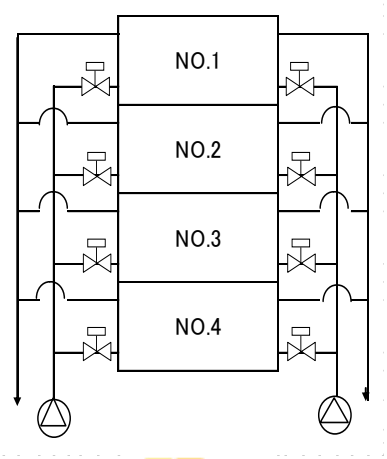
Evaporator	1.3 ~ 2.9 gpm/ton	0.29 ~ 0.65 m^3/h/ton
Absorber-Condenser (single effect)	3.0 ~ 8.0 gpm/ton	0.68 ~ 1.81 m^3/h/ton
Absorber-Condenser (double effect)	2.2 ~ 6.0 gpm/ton	0.49 ~ 1.36 m^3/h/ton

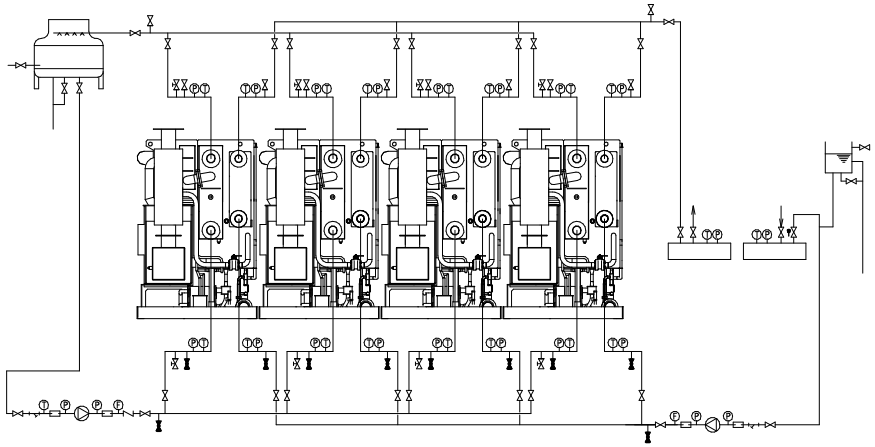
Enhanced Reliability
Key – Always Design With Less Salt %, More Water

- Always Design with Lower Lithium Bromide Salt Solution %
- Less Salt, More Water Keeps It Farther From Crystallization Zone
- Less Salt, More Water Makes It Easier To Boil
- Easier To Boil Means Lower Temperature and Pressure
- Lower Temperature and Pressure Means Lower Corrosion, Longer Life

Small Direct Gas Fired Chiller-Heater Residential, Small Commercial Applications

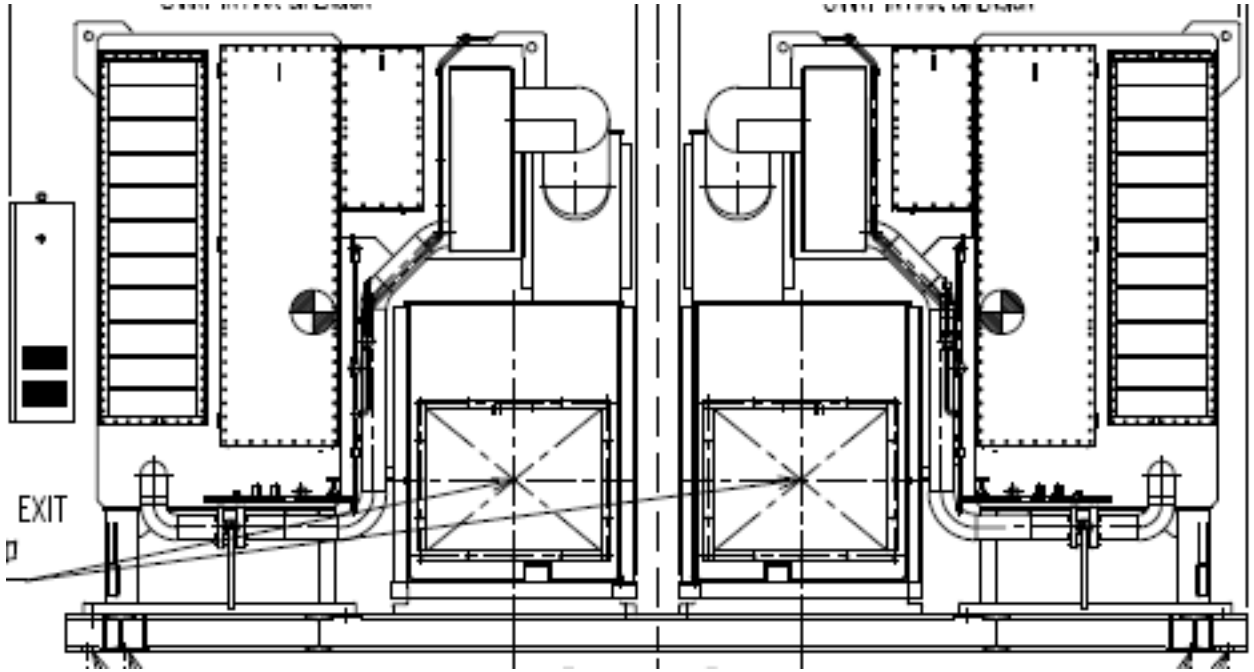
- Chilled water 2.4 gpm/ton, 54/44°F, 30 ~ 100 tons
- Heater 128/140°F, typically $ 1 MMBTU/h
- Cooling water 4.0 gpm/ton (85/95°F)
- Modular
- Easy Installation With Fork Lift
- Split Shipment
- Outdoor Capable





Convention Center
Direct Gas Fired Absorption Chiller-Heater

- Convention center in a large city in China
- Total cooling capacity 7,275 tons
- Natural Gas Fired
  - Cooling COP 1.41 (LHV)
  - Heating COP 0.95
- Chilled water
  - 57.2/44.6°F
  - Flow 1.9 gpm/ton
- Heating water
  - 122/140°F
- Condenser water
  - 86/98.6°F
  - Flow 3.2 gpm/ton

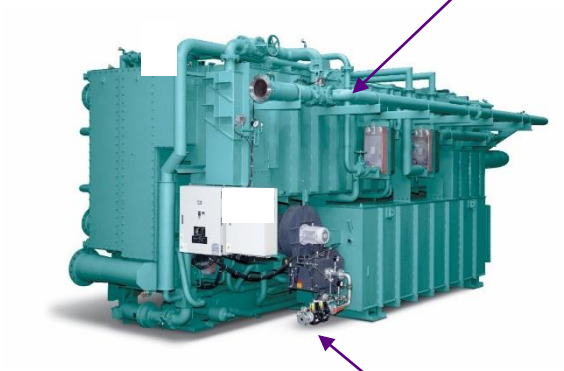


District Cooling
Hybrid Plant – Steam Absorption + Centrifugal

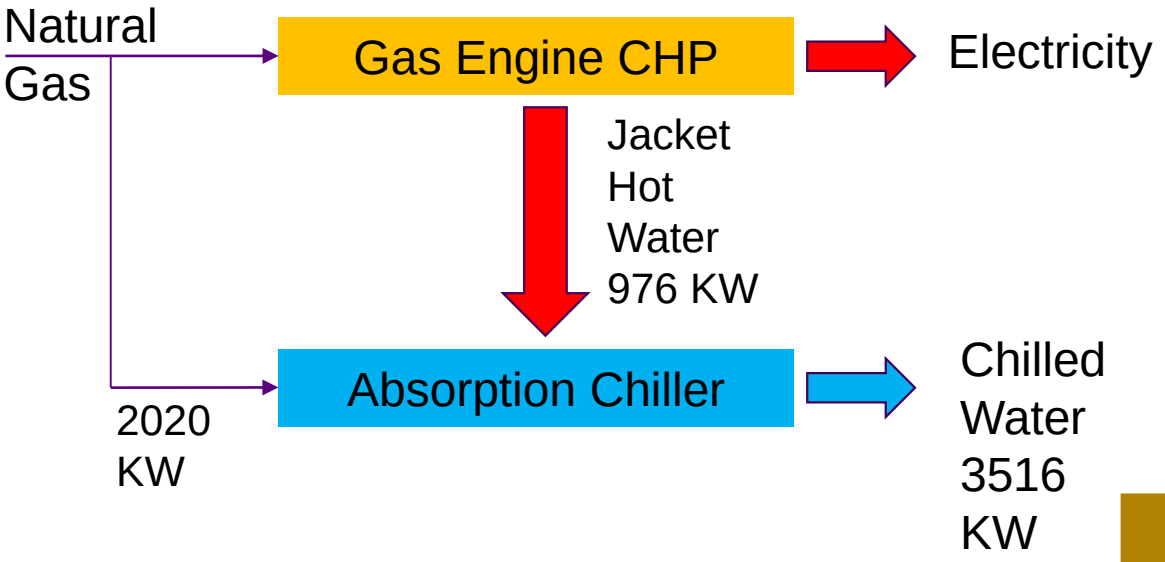
- Famous metro city in Japan
- Total cooling capacity: 25,840 tons
  - Steam driven absorption chillers 6,000 tons
  - Steam centrifugal 8,000 tons
  - Electric centrifugal 11,840 tons
- Ice thermal storage tank (23°F)
- Chilled water 55.4/42.8°F
- Condenser water 89.6/104°F
- Steam Source – gas fired boiler 118 psig

1000 Tons (3516 KW) Direct Fired + Hot Water Driven Natural Gas Input Saved By ~ 25%

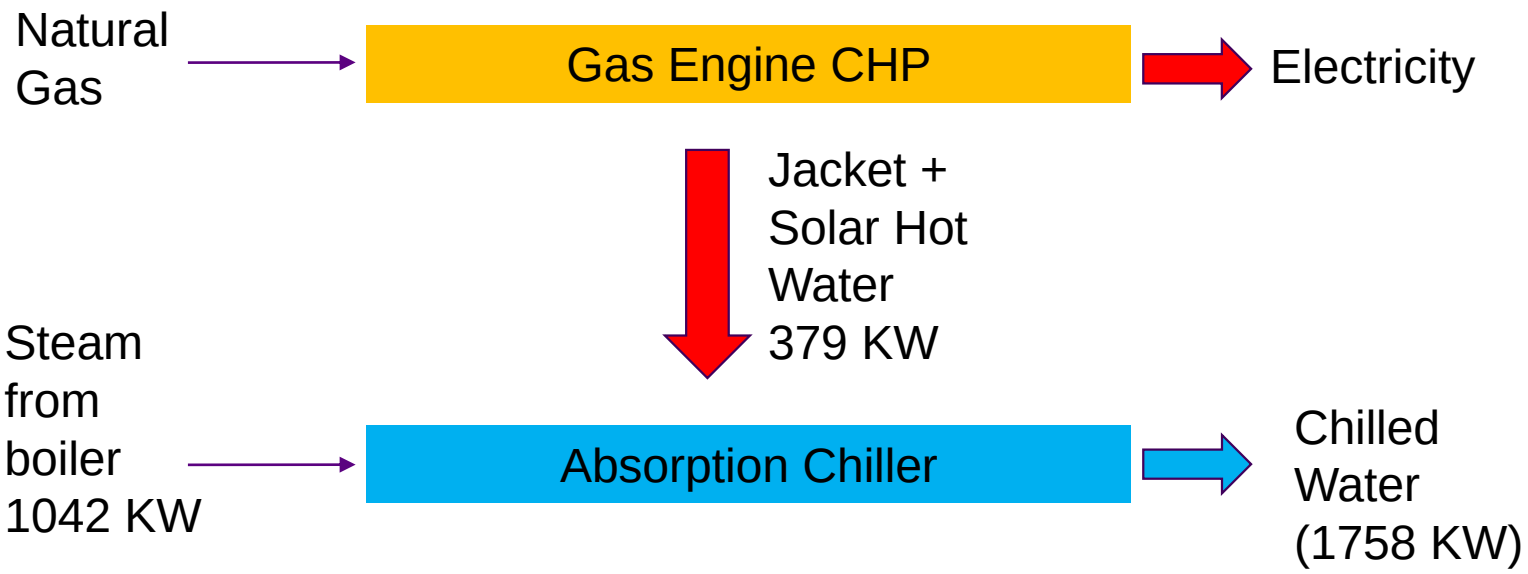
Supplemental Driving
Hot Water
From CHP (976 KW)



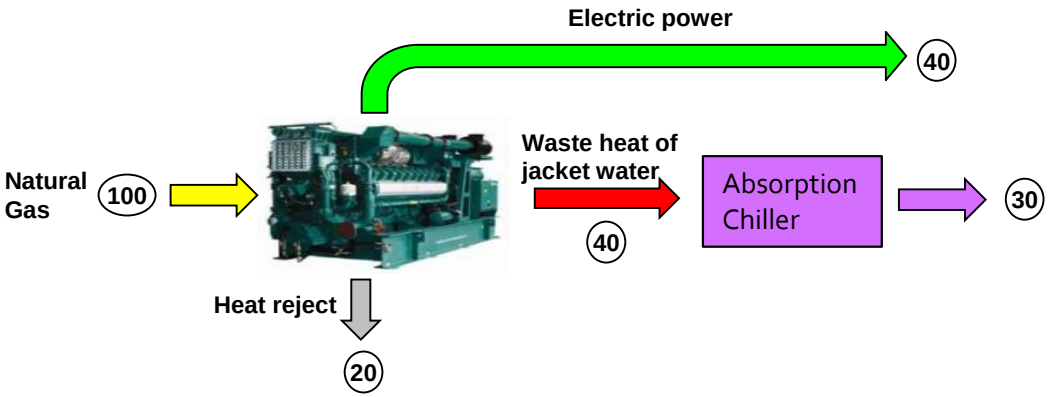
Natural Gas
Burner (2020 KW)



500 Tons (1758 KW) Steam + Hot Water Driven Steam Input Saved By ~ 15%



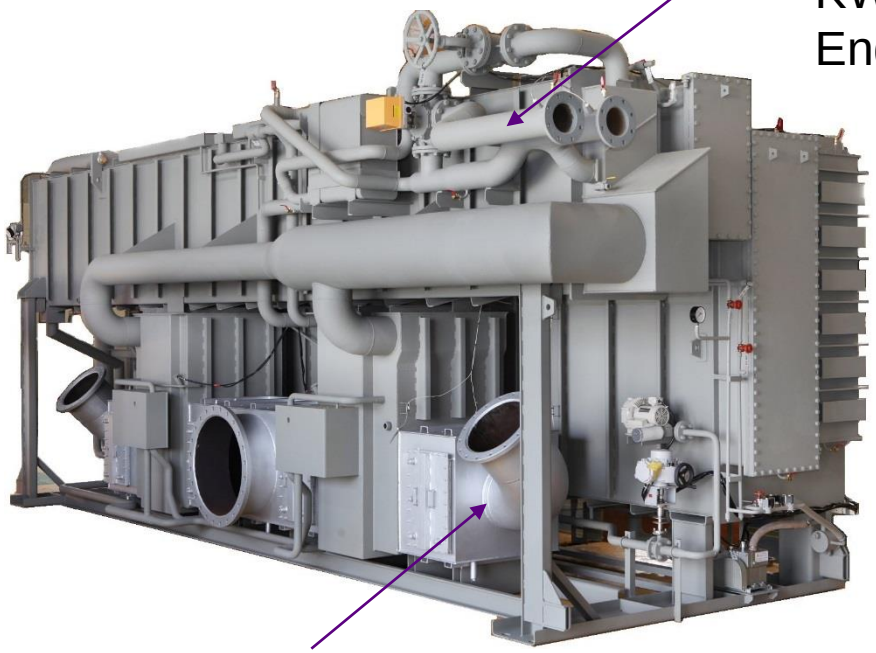
Hot Water Driven
Ideal for CHP (Gas Engine or Micro-Turbine)



- Typical Driving Hot Water
  - 209/194°F
  - 194/176°F
- Or as low as 203/131°F

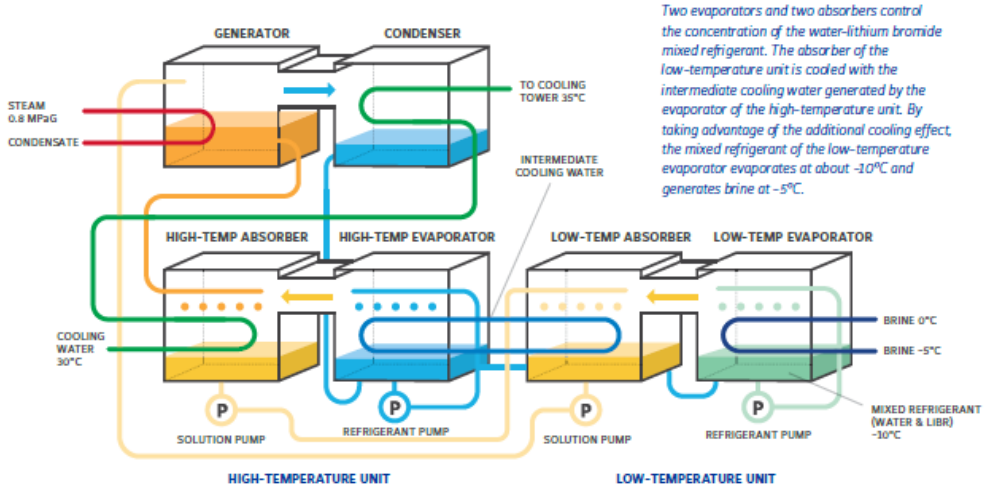
Gas Engine CHP – Data Center Exhaust Gas + Hot Water

- Cooling Capacity 1436 Tons (5,050 KW)
- Chilled Water 65/54°F
- Condenser Water 90/100°F
- Exhaust Gas (CHP) 858/302°F
- Driving Hot Water (CHP) 192/162°F
- Back-up Natural Gas Burner



Leaving Evaporator As Low As 23°F (-5°C) Breweries and Dairies

Typical Driving Heat Source Steam 100 ~ 125 psig or direct gas fired

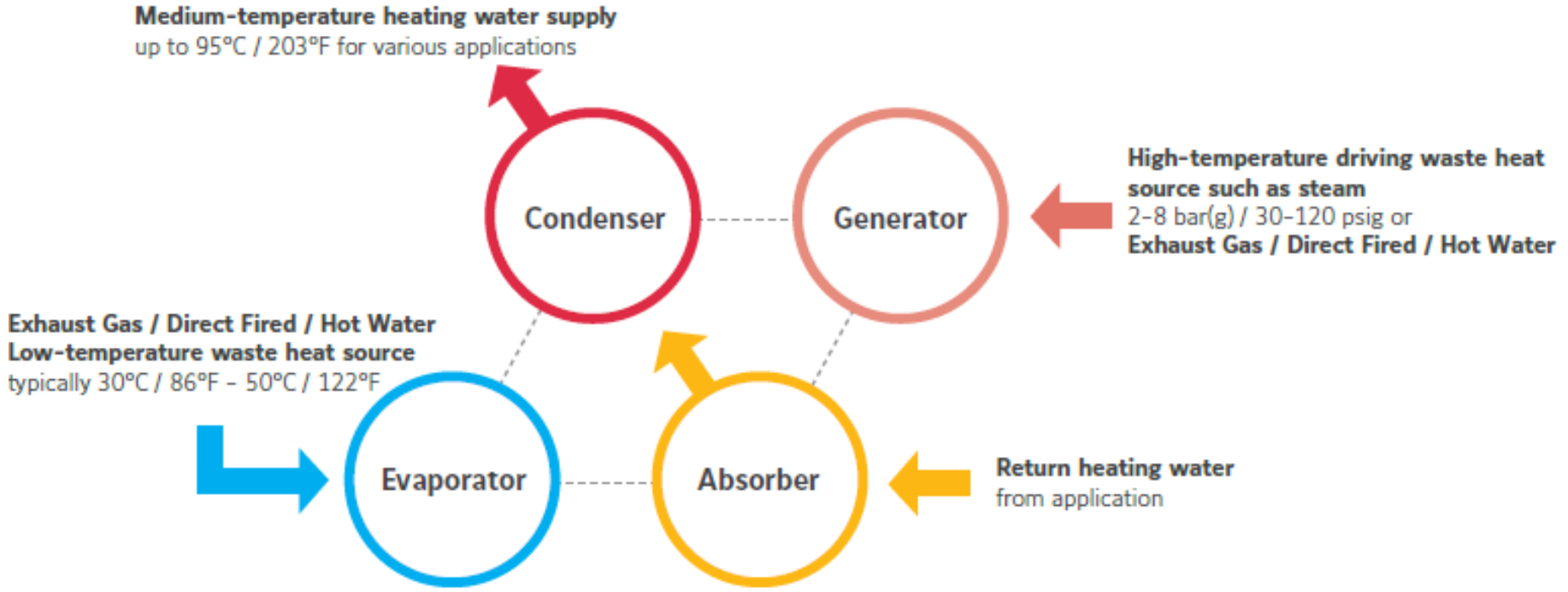


Leaving Evaporator 23°F (-5°C)

CHP and Sustainability On Ocean!

- Innovative application withstanding rolling and pitching angles during the cruise
- Driving hot water 194°F from gas engine powering the ship
- Sea water cooled condenser, wide range of temperatures
- Avoiding dumping the waste heat in the ocean, thereby making the ship more sustainable

Heat Pump – Sustainable District Heating
1 ~ 40 MW Heating



Recap

- Absorption Chillers Are Cost Efficient, Flexible and Reliable
- Deployed For Numerous Cooling and Heating Applications
- Low Carbon Cooling Heating Solution

Questions?

Johnson Controls

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https://www.districtenergy.org/events/webinars/past-webinars

http://york.com/absorption-chillers

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