Introduction to CO_2 Heat Pumps

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MHI GROUP MITSUBISHI HEAVY INDUSTRIES

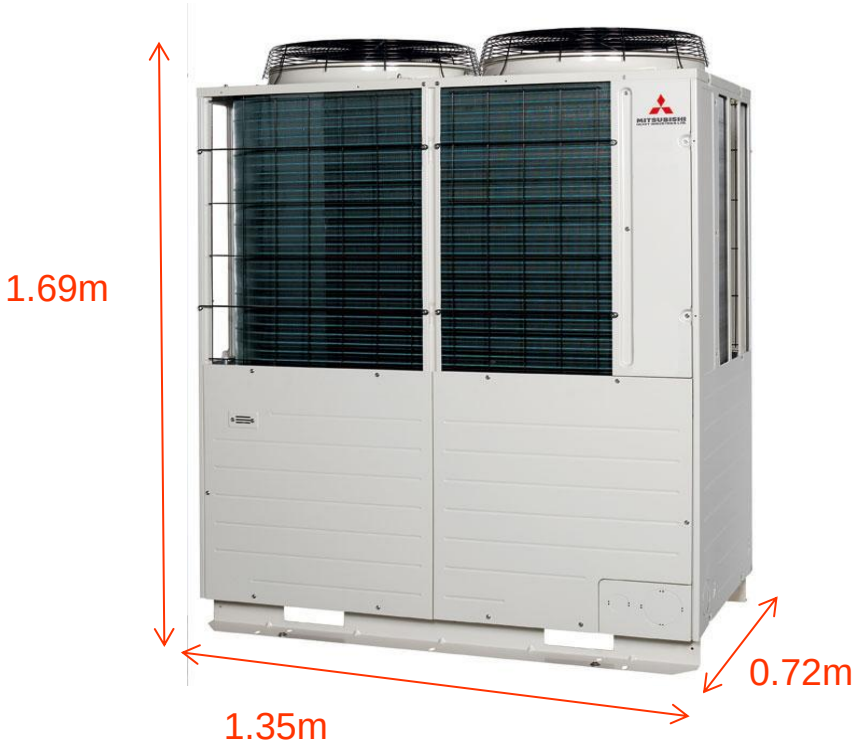
CO_2 Refrigerant

- CO_2 / carbon dioxide or alternatively R744 Sits outside all F gas regulations
- Natural refrigerant
- CO_2 is a safe alternative refrigerant to other alternatives
- Produce high temperatures when under pressure up to 140 degrees Centigrade
- .Operates under higher pressure 90 to 130 bar

Features

Modular Output Capacity
30 – 480 KW

- Suitable for retrofit or new build project
- Fixed Water off and storage temperature control
- Modular system from 30 to 480 kW output [1 to 16 Q-ton's]
- CO_2 natural refrigerant also known as R744
  - Global Warming Potential [GWP] : 1
  - Ozone Depletion Potential [ODP] : 0
- Hot water supply from 60 to 90^{o}C even at (minus) -25^{o}C ambient temperature
- User friendly and comprehensive touch screen control panel.



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Features (Continued)

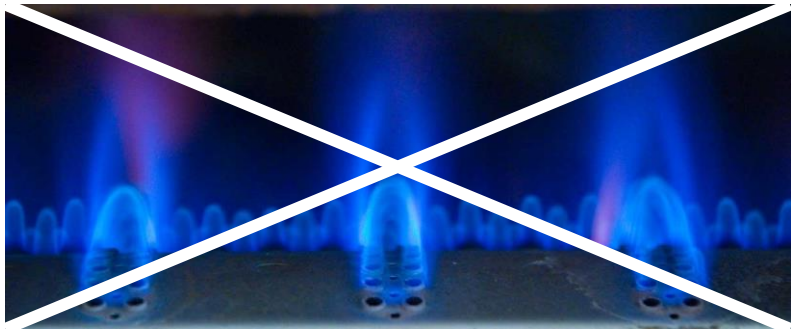
- No output capacity reduction down to -7°C
- In-built water pump securing a constant water off temperature
- CO_2 Heat pump runs like a boiler, with no heating backup requirement
- Water supply at 65°C = 500 l/h
- Water supply at 90°C = 300 l/h
- Super quiet operation – 52dB(A) at 1m
- CO_2 heat pumps are an established method of hot water heating in Japan
  - ♦*Tried and tested technology*
- Over 10 million CO_2 heat pump systems have been installed in Japan [to date]
  - ♦*Established pedigree of performance*

To produce 90°C hot water at -7°C ambient, Q-Ton consumes 64% less energy (COP=2.8) than an electric water heater

- ♦ *Reduced energy bills and carbon emissions*

Features (Continued)

- CO_2 heat pumps can replace standard gas fire boilers, with no heating backup requirement



- CO_2 heat pumps are an internationally established method of heating hot water
- CO_2 heat pumps are suitable for most commercial application with a large sanitary water consumption
- Cold water feed is taken directly from the main cold water supply. The larger the temperature differential between incoming cold water and outlet temperature increases the efficiency of the system
- The level of efficiency achieved with a CO_2 heat pump is related to the development of a highly efficiency compressor. This has resulted in the substantial improvement of COP performance

World's First Two Stage compressor

- Q-ton uses the World's FIRST 2 stage CO_2 inverter compressor
- CO_2 + two stage scroll-rotary compressor = **Outstanding seasonal efficiency - 400%** (water supply at 65°C)

Reason for high efficiency

Scroll + rotary compressor

Two-stage compressor
By combination of two systems, high efficiency has been achieved in all operation conditions.

Scroll system advanced at high pressure ratio

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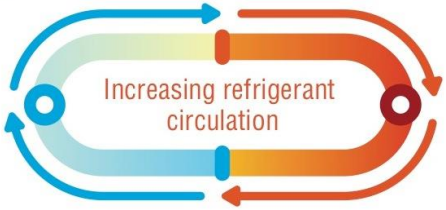
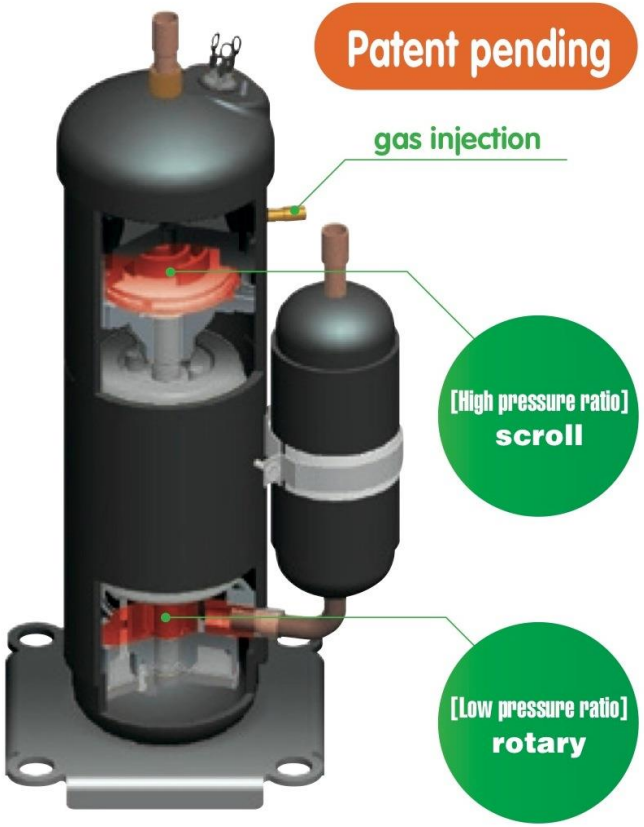
Rotary system advanced at low pressure ratio

Intermediate pressure gas injection configuration

By increasing refrigerant circulation, high efficiency in low temperature can be achieved.



Patent pending



Specifics of a Two Stage compressor

2 stage compressor - Most CO_2 heat pumps have a single stage compression and not many are fitted with a two stage compression. The ones using 2 stage compressors (rotary to scroll) exhibit significantly improved performance at cold outside air temperatures.

The low stage has a rotary compressor mechanism that provides good compression efficiency at low-pressure ratios, while the high stage has a scroll compressor that provides good compression efficiency at high-pressure ratios. The inside of the housing is designed for medium pressure. This configuration offers the following advantages.

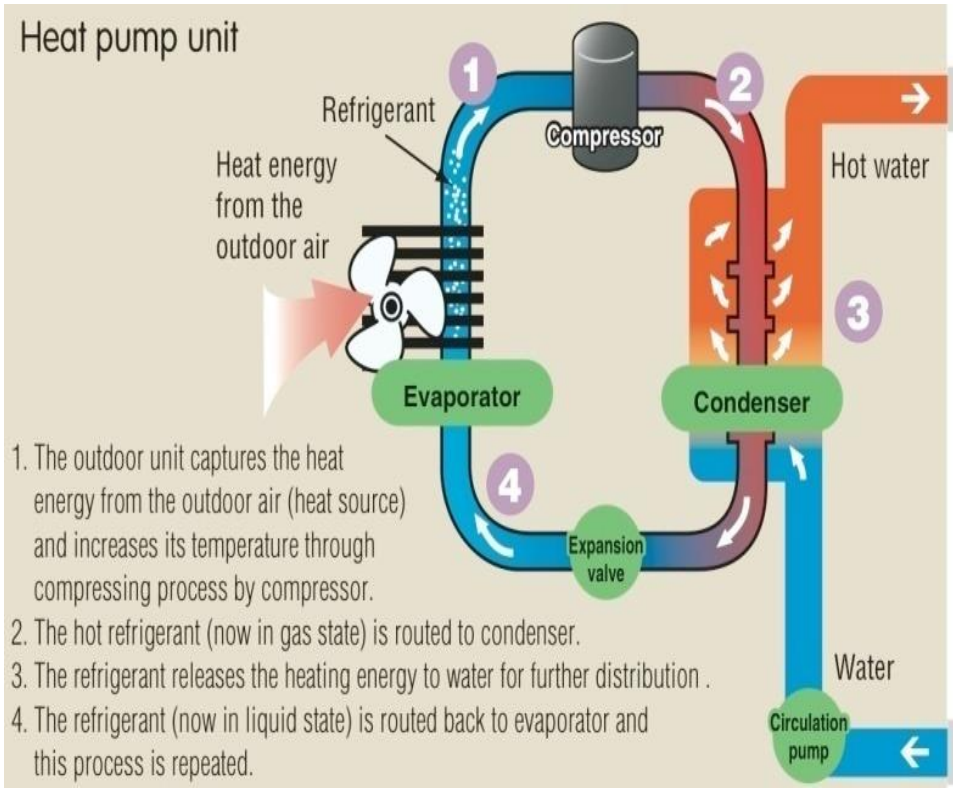
1. The two-stage compression reduces the leakage loss during the compression stroke, and provides high compression efficiency.
2. Refrigerant gas injection into the medium-pressure housing between the two compression stages enables increased refrigerant recirculation on the heating side (gas cooler), and increases the heating capacity

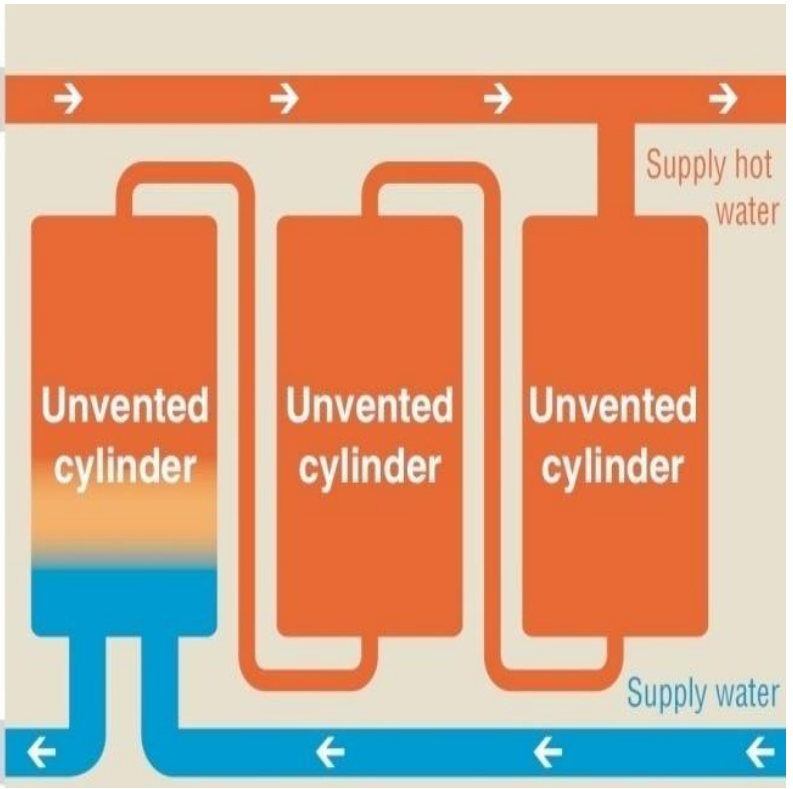
This two-stage compression allows for the use of optimum medium pressure and control of the quantity of gas injected. The refrigerant is separated into liquid and gas after expansion, under optimum medium-pressure conditions, the gas-cooler refrigerant recirculation and heating capacity are increased in comparison to a single-stage compression cycle with direct gas inhalation into the compressor. The decreased amount of recirculated liquid refrigerant that flows into the vaporizer reduces the electric consumption in the compressor and increases the energy efficiency.

Traditional Heat Pumps vs. CO_2 Heat Pumps

Traditional Heat Pumps	CO_2 Heat Pumps
Maximum water temperature is 55^0C – 70^0C is achievable but with a heat element	90^0C achievable without additional heating backup
No control on the water temperature supply at low ambient conditions	Constant water supply temperature
Reverse cycle defrost system with the need of a buffer tank	Hot gas defrost system using the energy from the compressor
Low efficiency	High efficiency
Various output ranges	Modular system
Standard water storage cylinder (with mixed water)	Stratified water tank
Efficiency relies on ambient conditions	Efficiency relies on incoming water temperature
Water flow control and water circuit design issues	Built-in inverter water pump and simple installation
Seasonal COP below 2	Seasonal COP >= 4

How a CO_2 heat pump works?

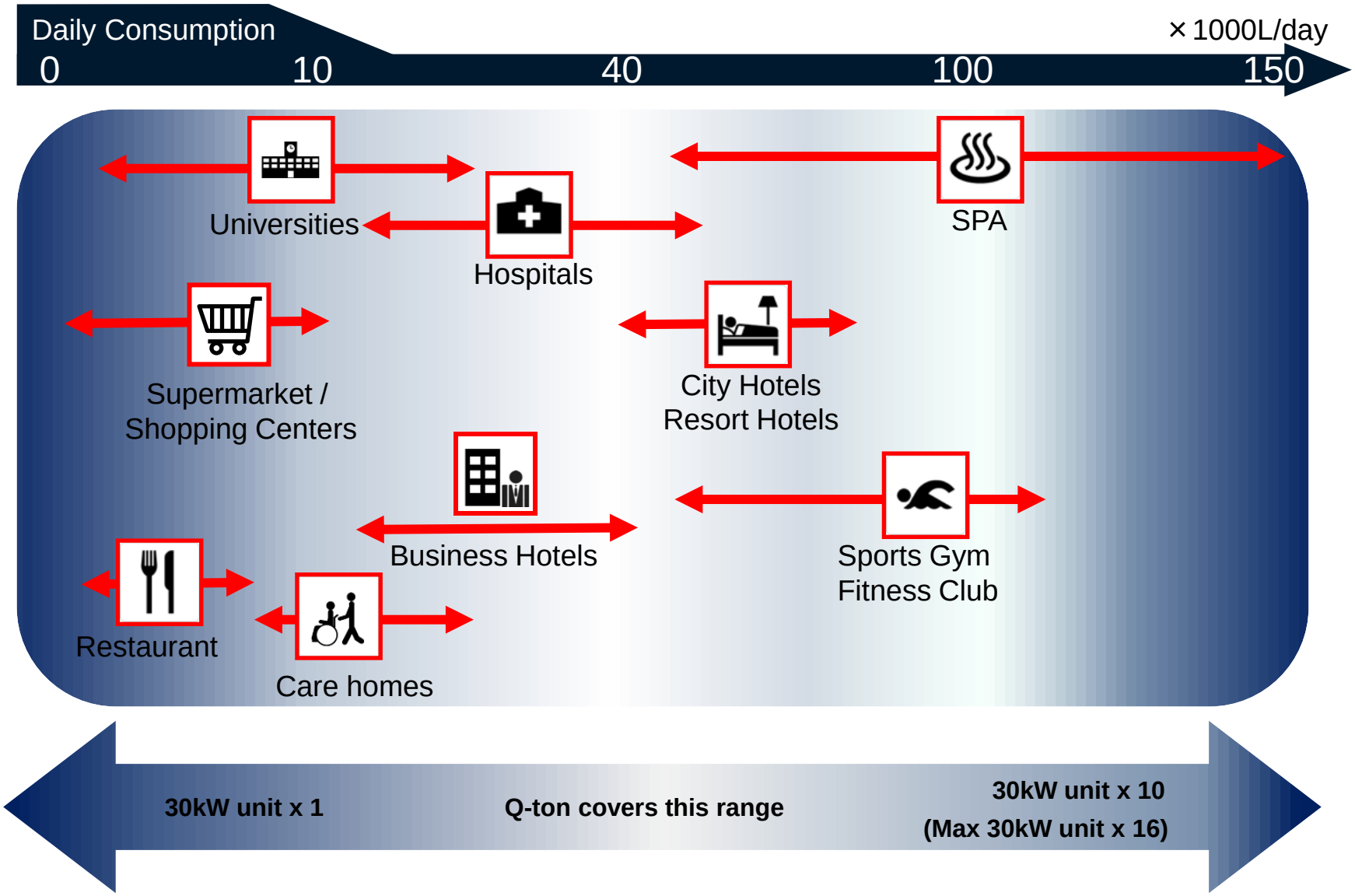




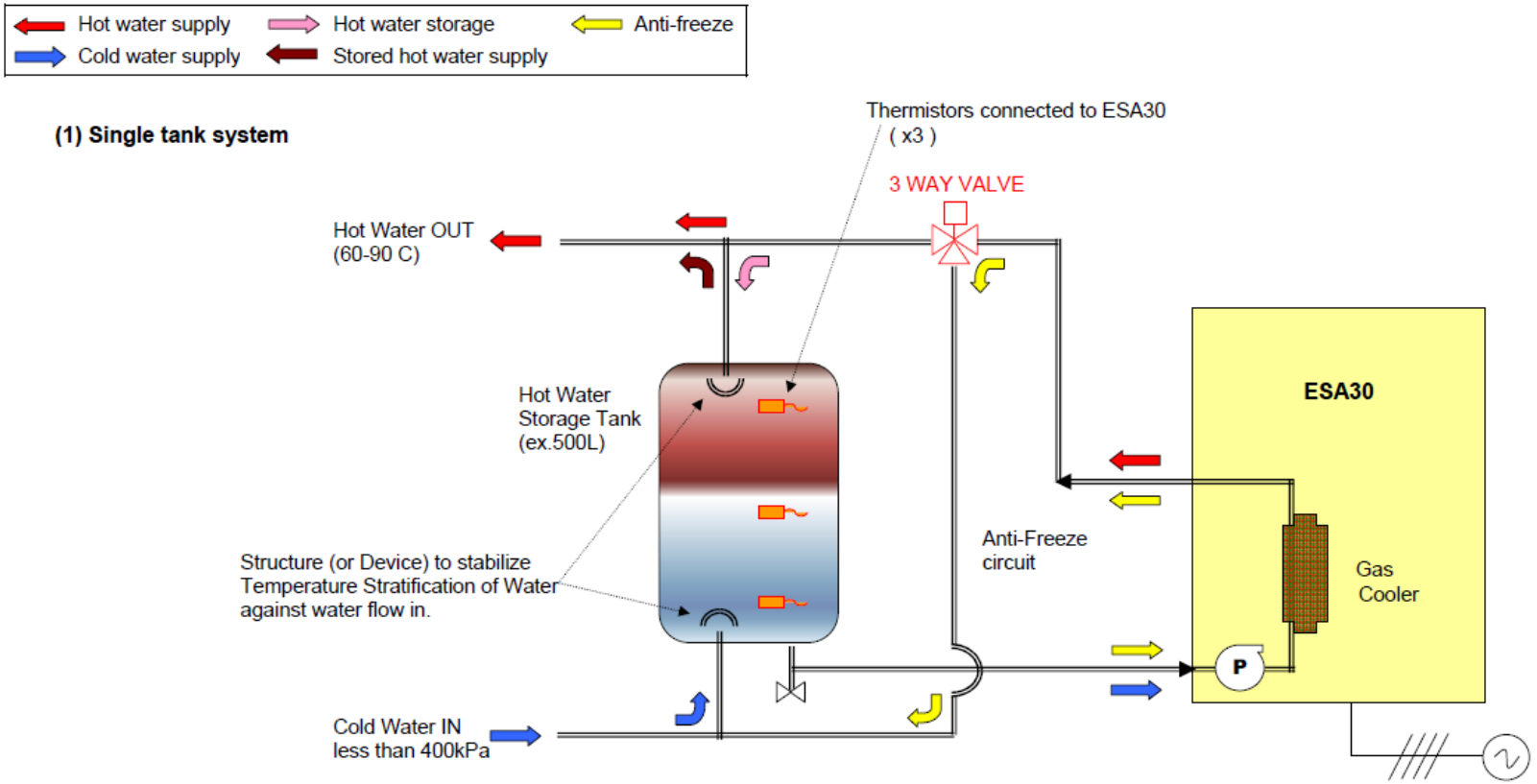
CO_2 Heat Pump

Special design water tank

Market Applications

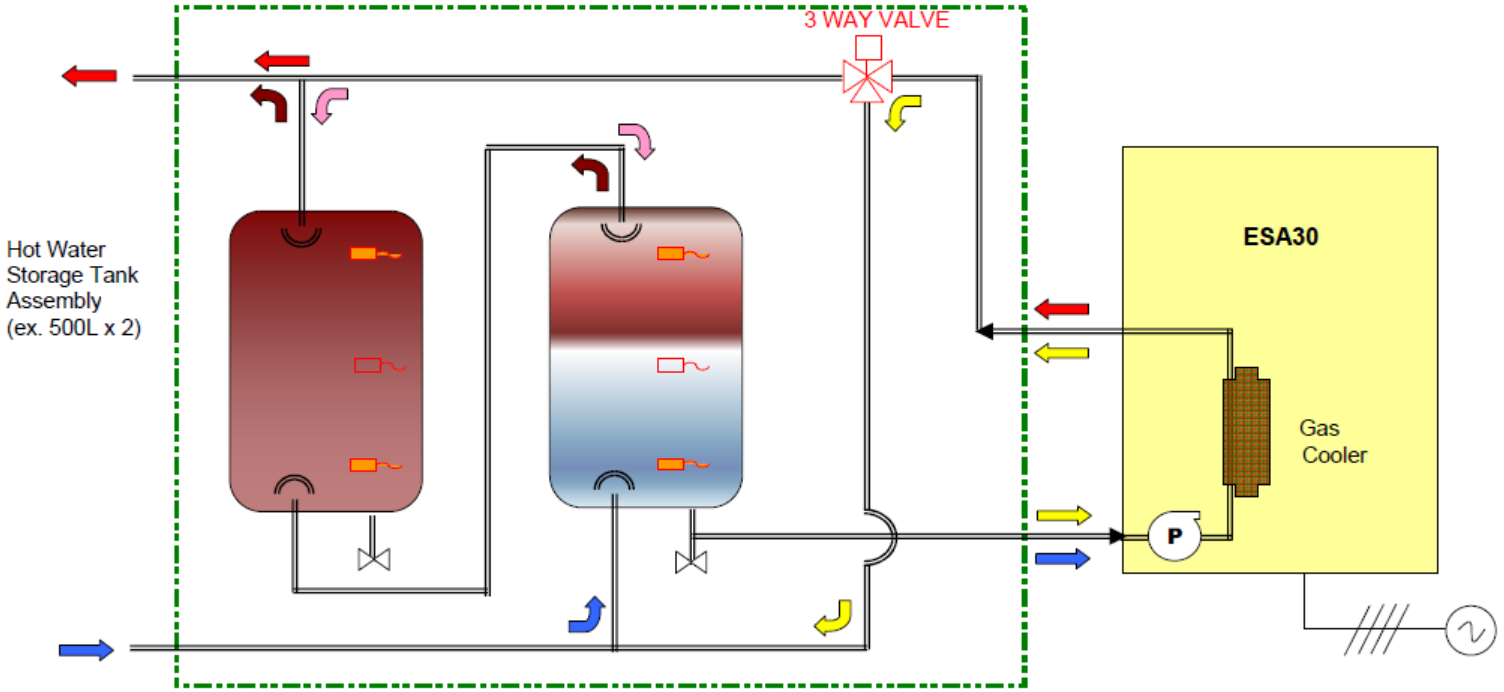


Installation schematic – Retro Fit

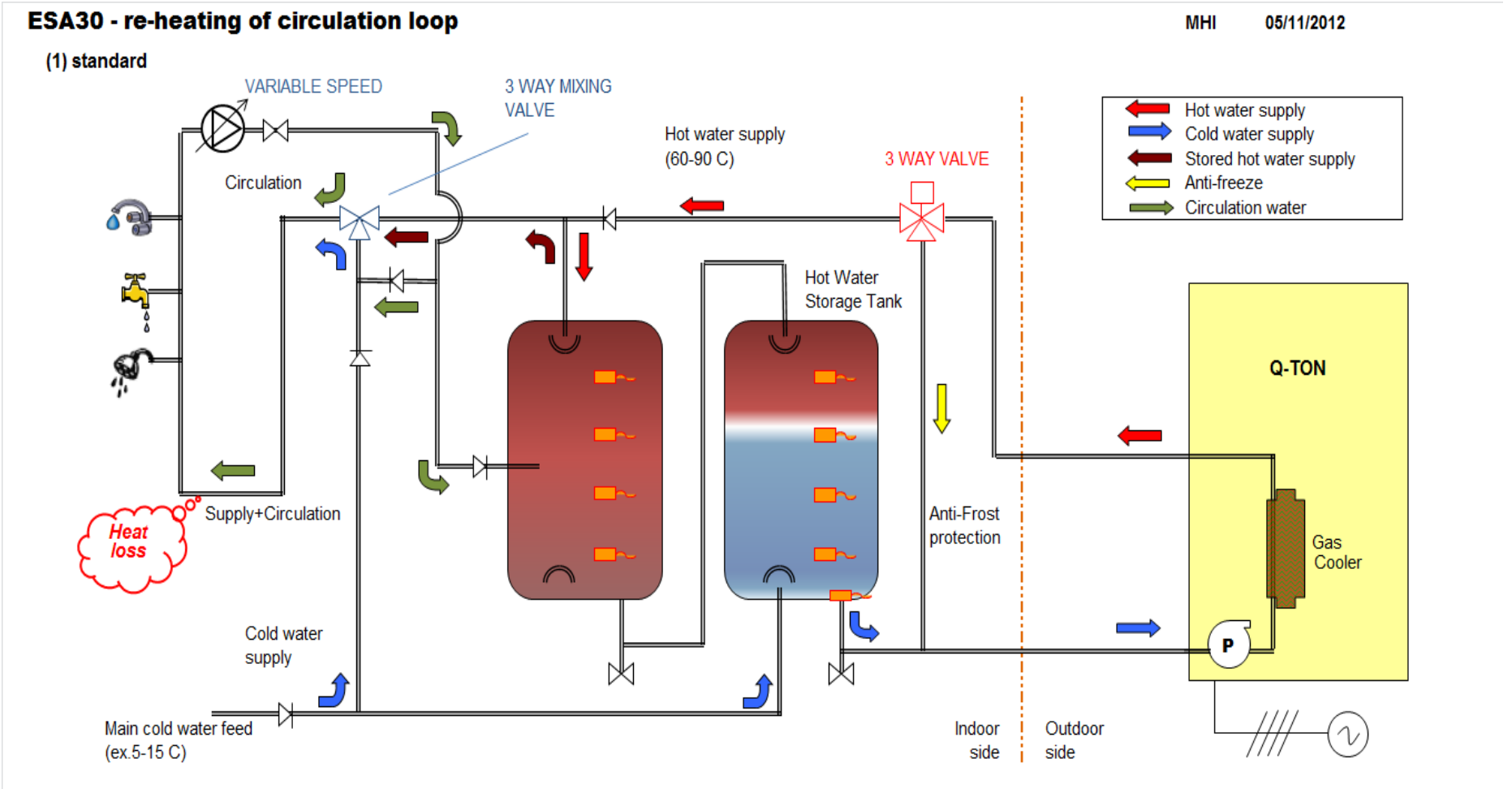


Installation schematic – modular water tanks

(2) Tank assembly (piping diagram for modular tanks)

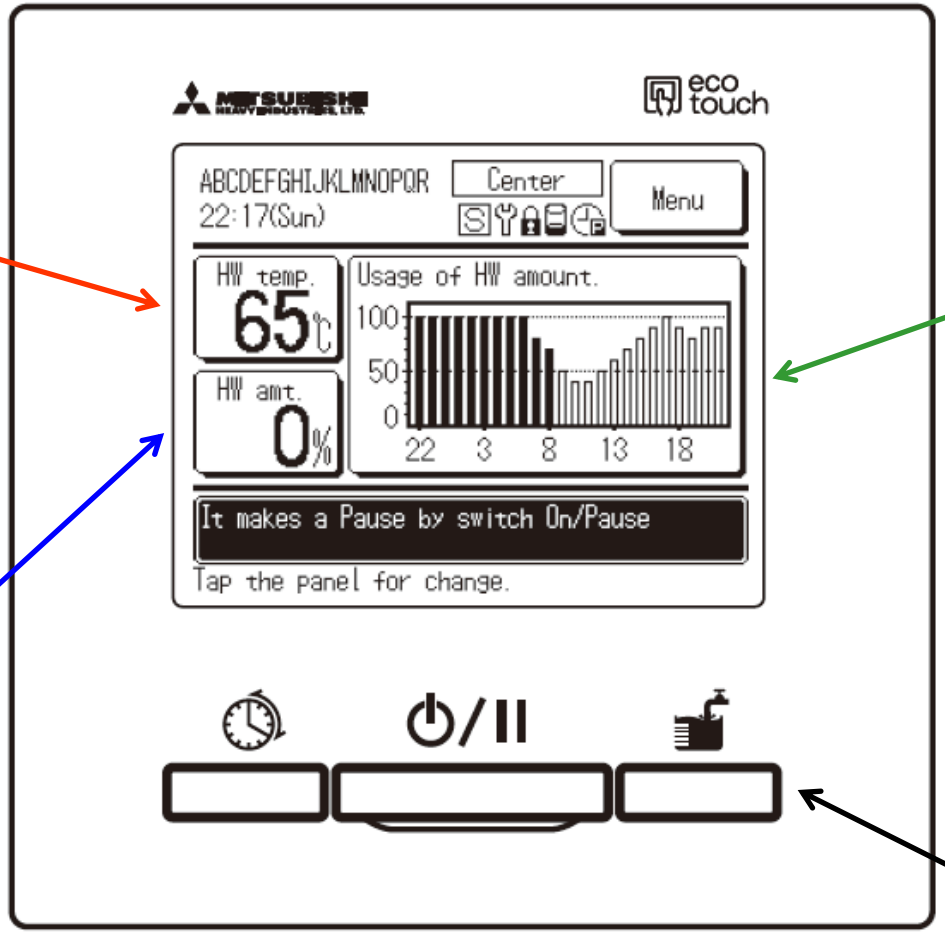


New Build Re-heating of circulation loop



Comprehensive touch screen controller

Stored water temperature



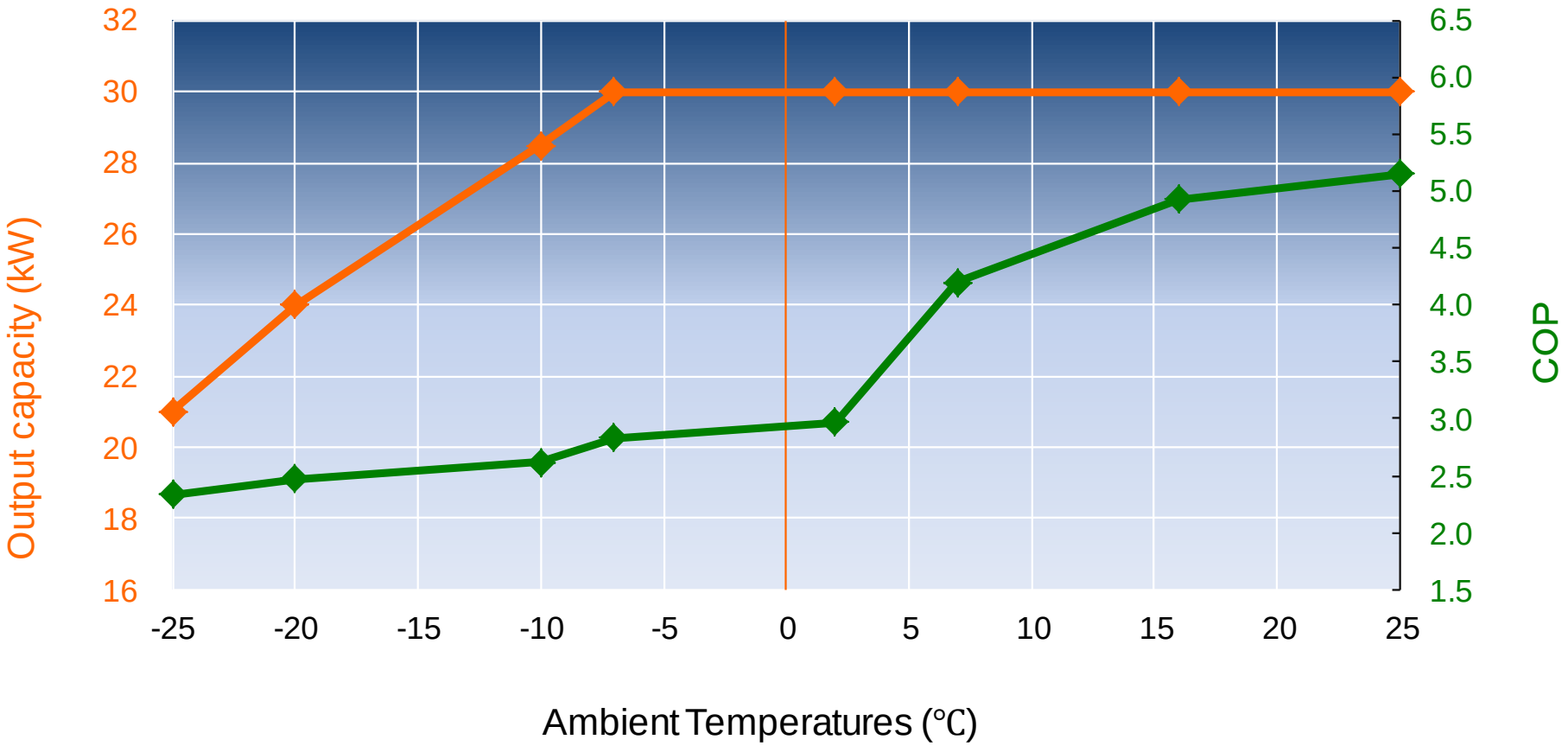
Visualization of the daily hot water consumption

Hot water storage volume
(% of the total storage capacity)

Forced button
(Override the timer setting)

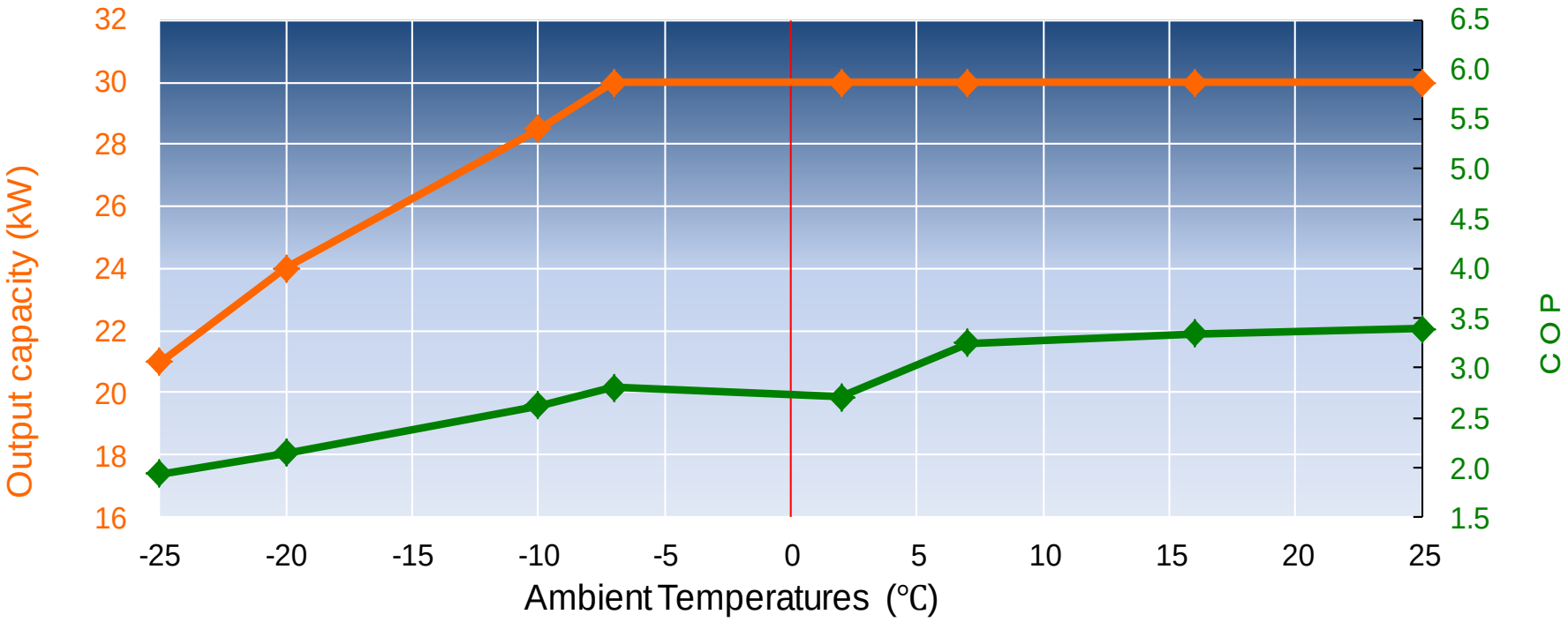
Heating performance at 65 degrees

Water inlet temperature = 5°C
Water outlet temperature = 65°C



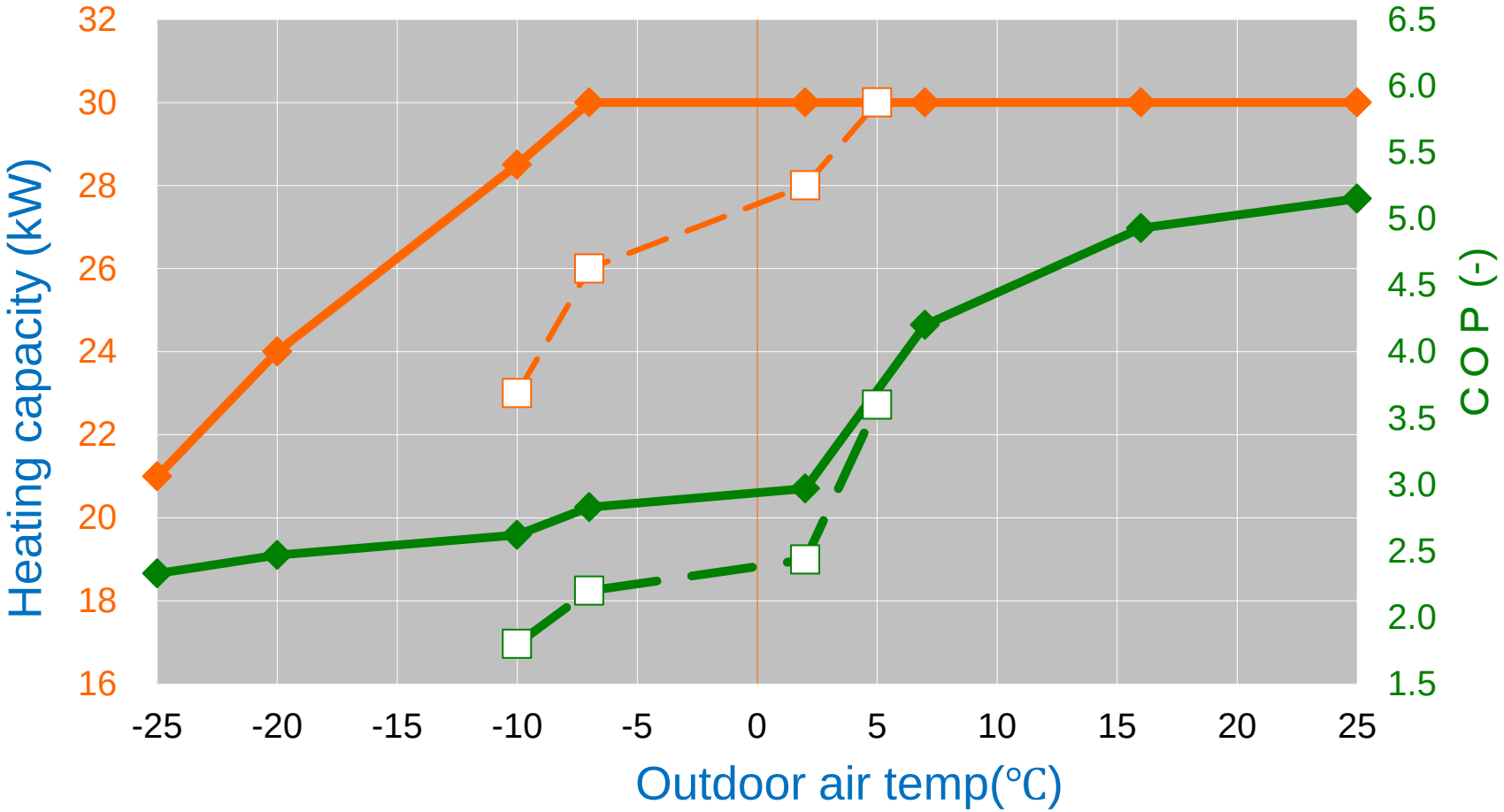
Heating performance at 90 degrees

Water inlet temperature = 5°C
Water outlet temperature = 90°C



Heating Performance characteristics curve

Water inlet temperature = 5°C
Water outlet temperature = 65°C



Questions