# Integrating heat pumps in heat networks - 60/30

CIBSE CPD SAV

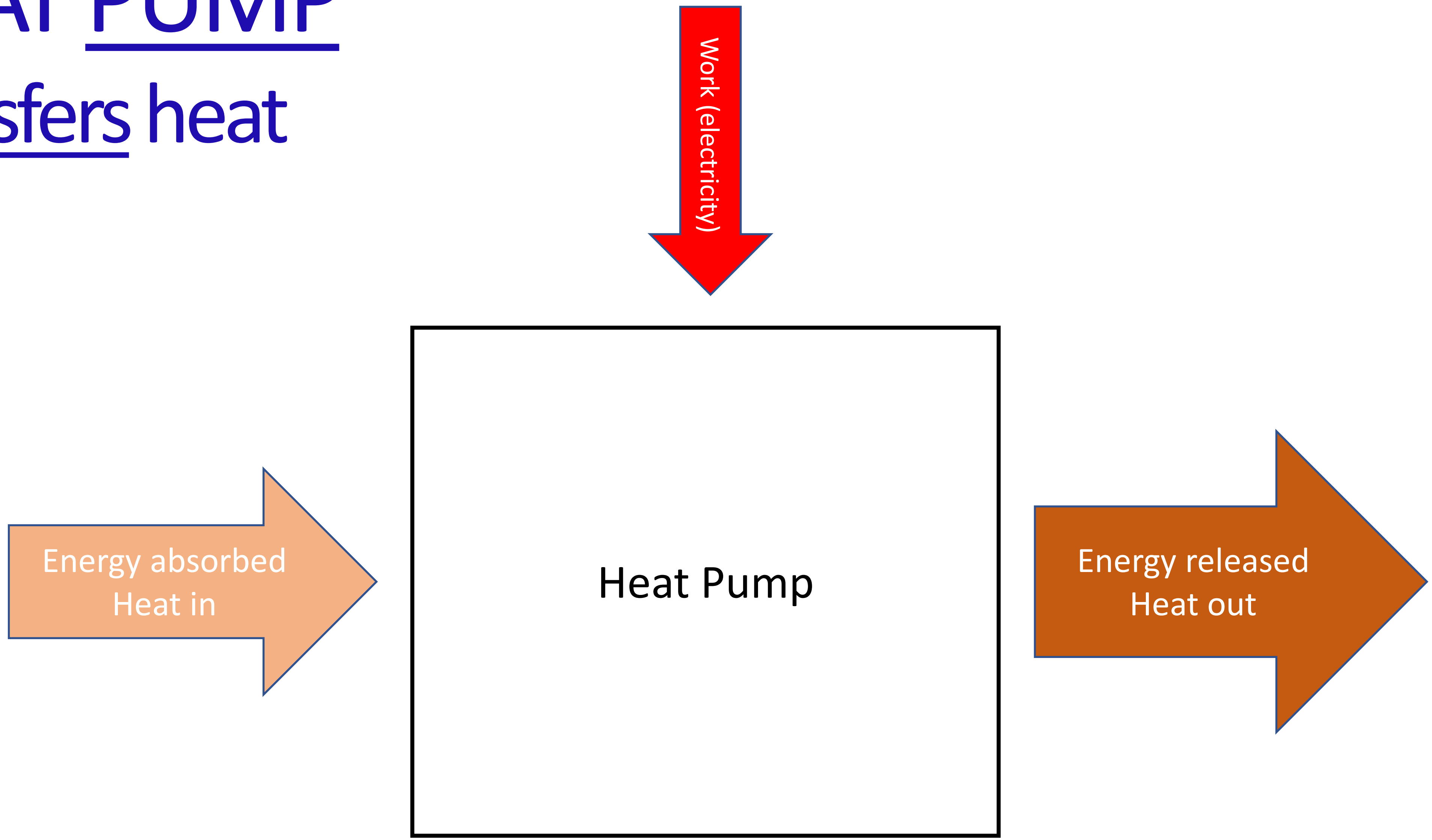
# Energy trilemma

# Design choices – 150 apartments

| HP only |
|---|
| 100% share |

| HP + CHP + boiler |
|---|
| 45% + 40% + 15% |

# HEAT PUMP transfers heat



SAV

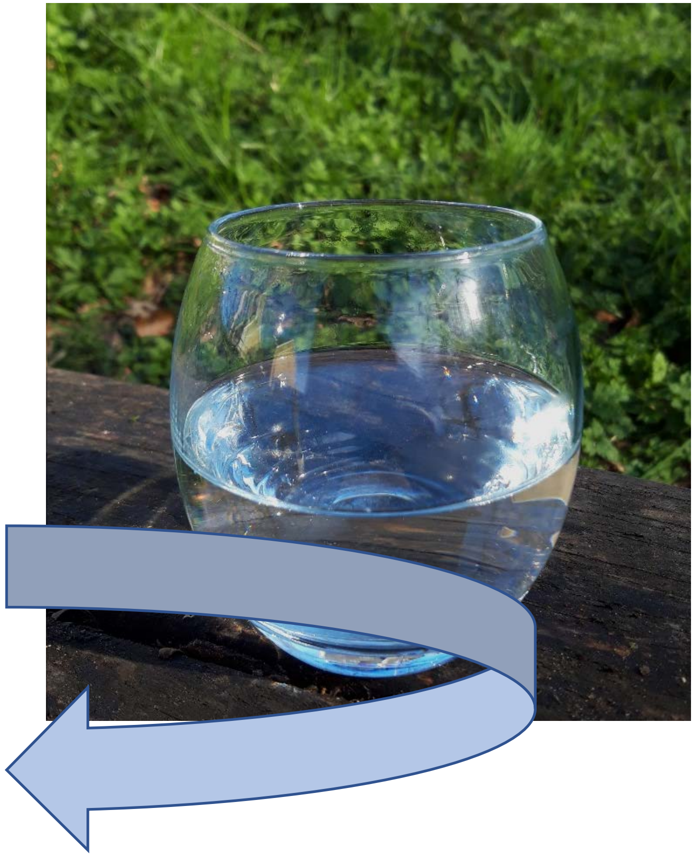
Electricity

Heat Pump

300%!!!

COLD

WARM



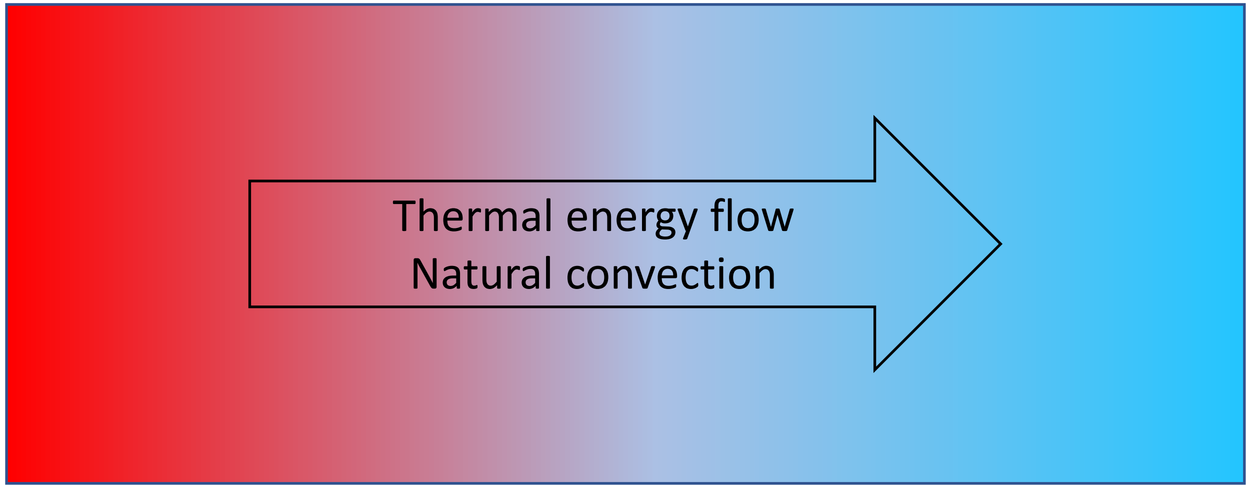
AIR

7°C outdoor temperature

Temperature difference is a must for heat transfer

# Heat transfer

High temperature (warmer)



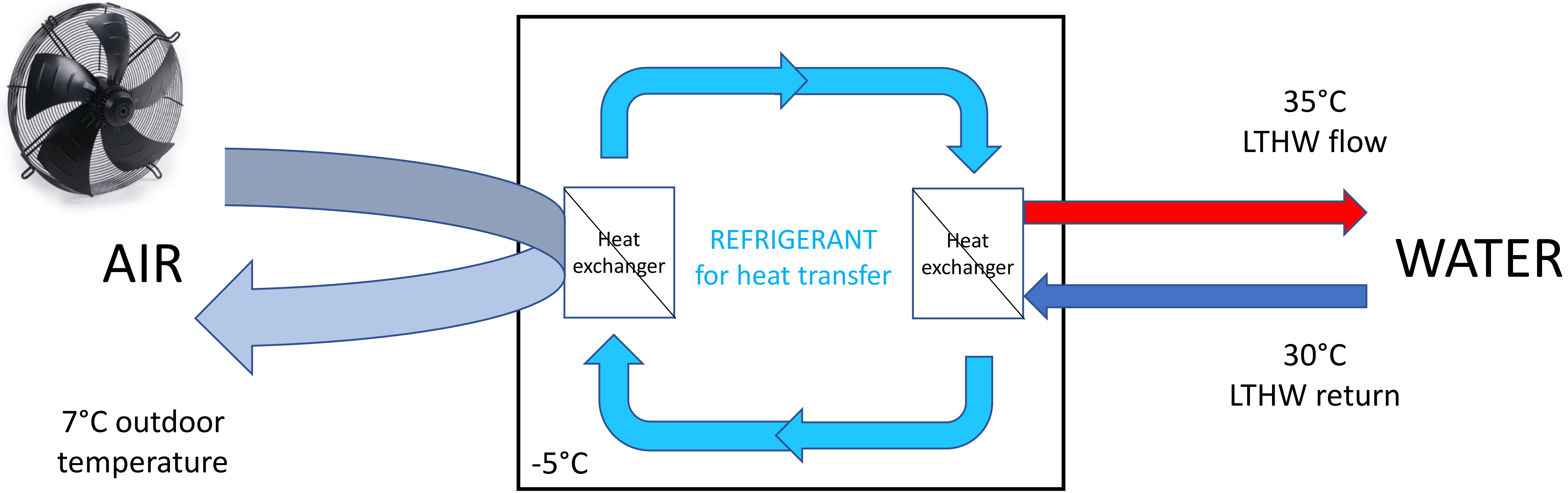

Low temperature (cooler)

How do we move heat from a cooler area to a warmer area?

# REFRIGERANT
# transfers heat

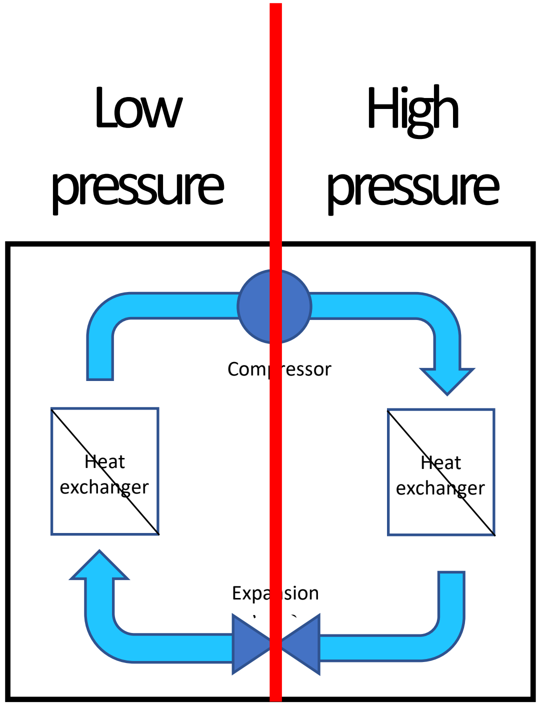
## Example:
## refrigerant R407C
## approximate temperatures

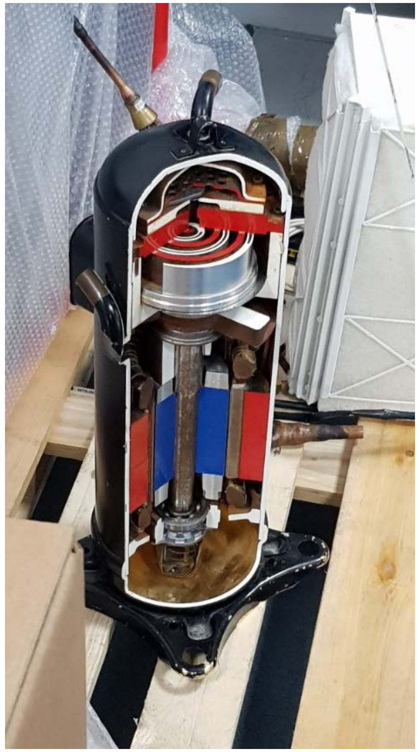
Boiling point -44°C at atmospheric pressure



# Compressor - pressurizes and circulates refrigerant

- compressor increases the pressure of a gas
- compressor is similar to pump:
  - ✓ increase the pressure on a fluid
  - ✓ can transport the fluid through a pipe

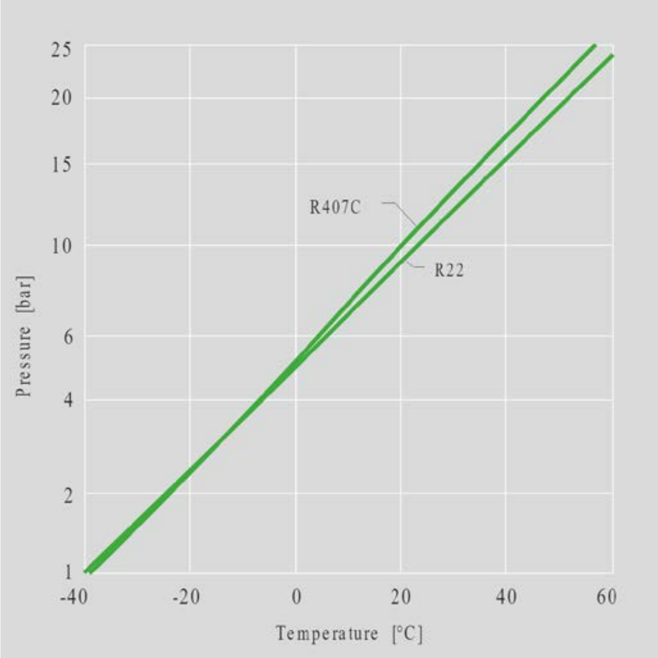


# Heat pump relies on refrigerant
# pressure / temperature relationship

- temperature and pressure of a gas are proportionally related at a constant volume

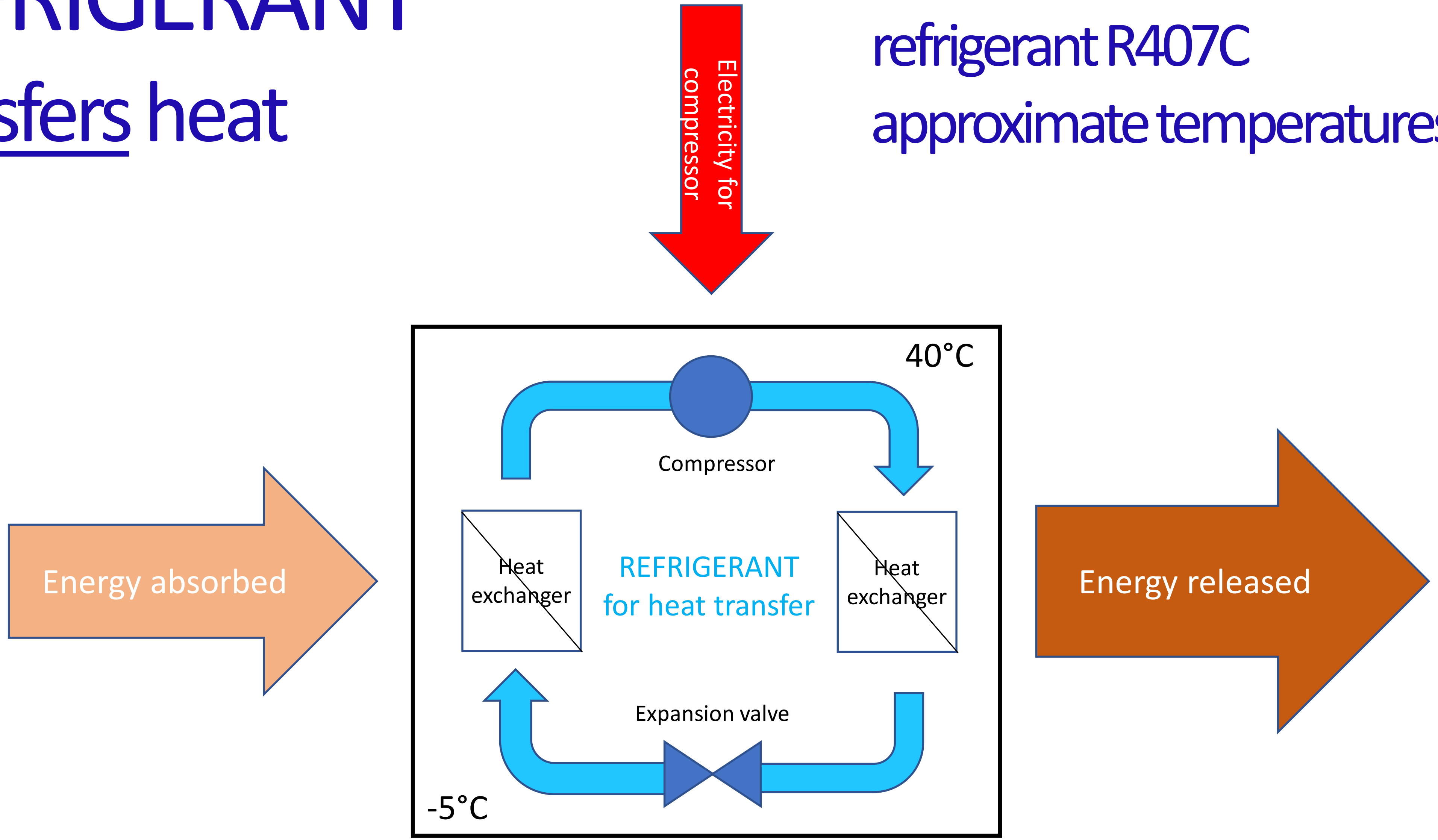
- pressure is increased – temperature rises



# REFRIGERANT

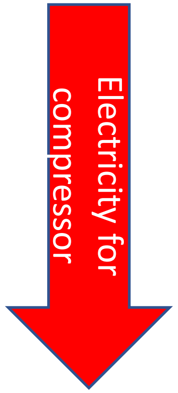
## transfers heat

Example:
refrigerant R407C
approximate temperatures

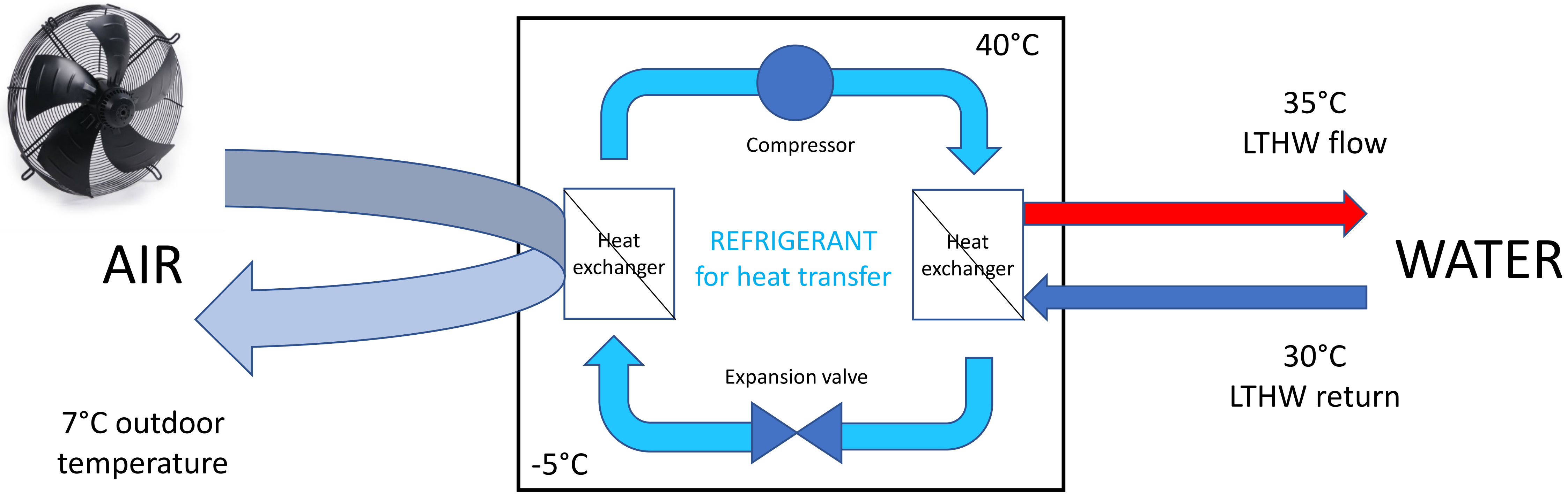


# REFRIGERANT

## transfers heat

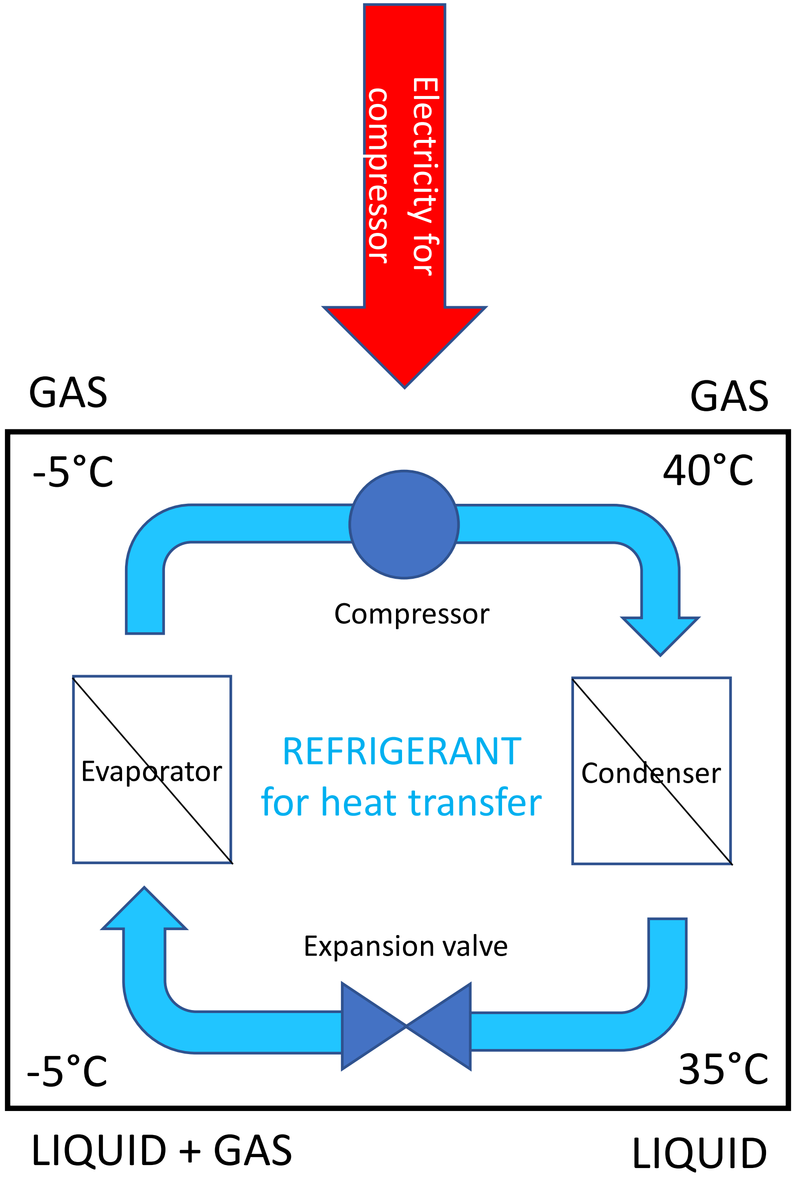



Example:
refrigerant R407C
approximate temperatures



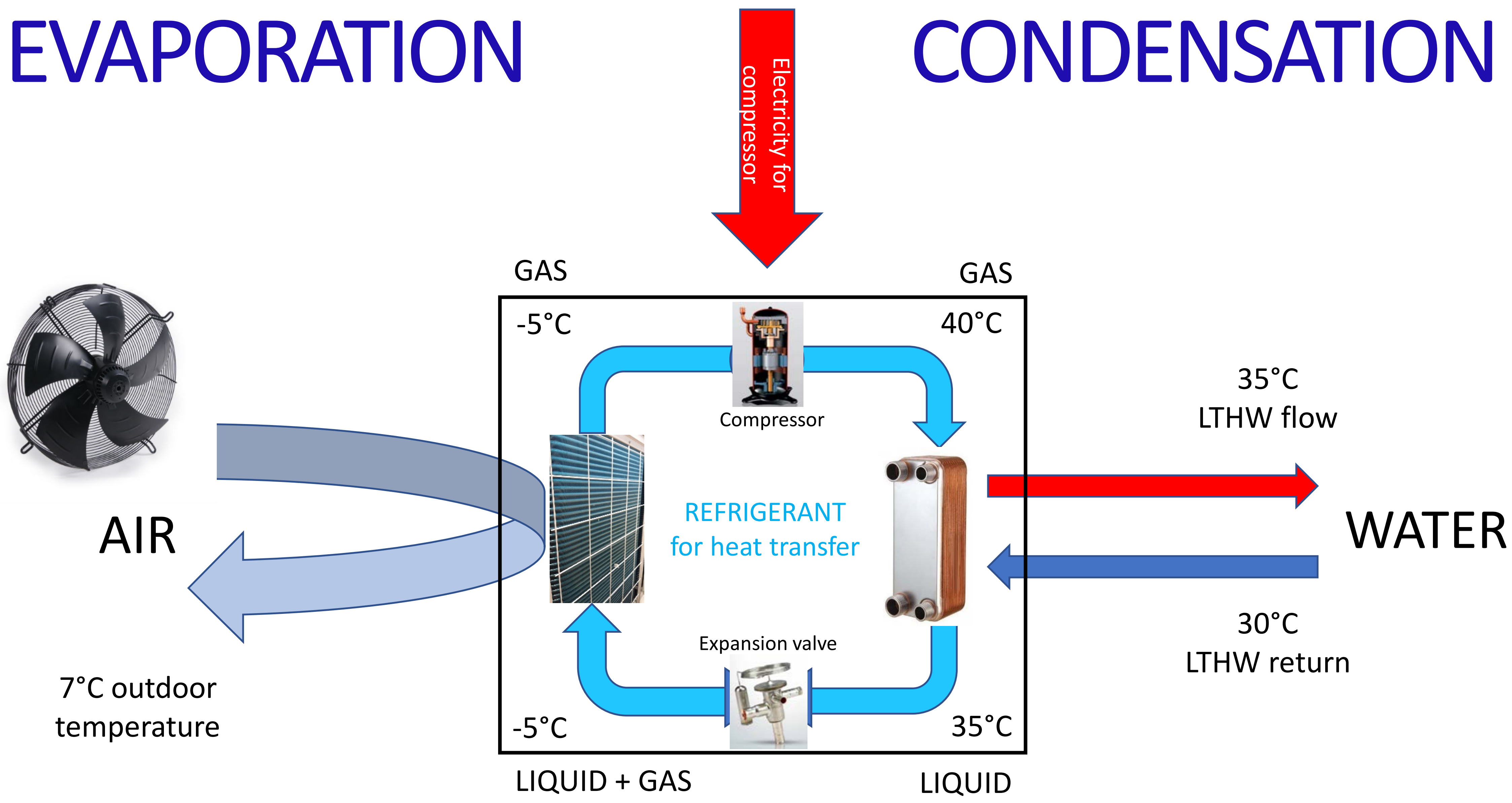
During evaporation heat is absorbed

Energy absorbed




During condensation heat is released

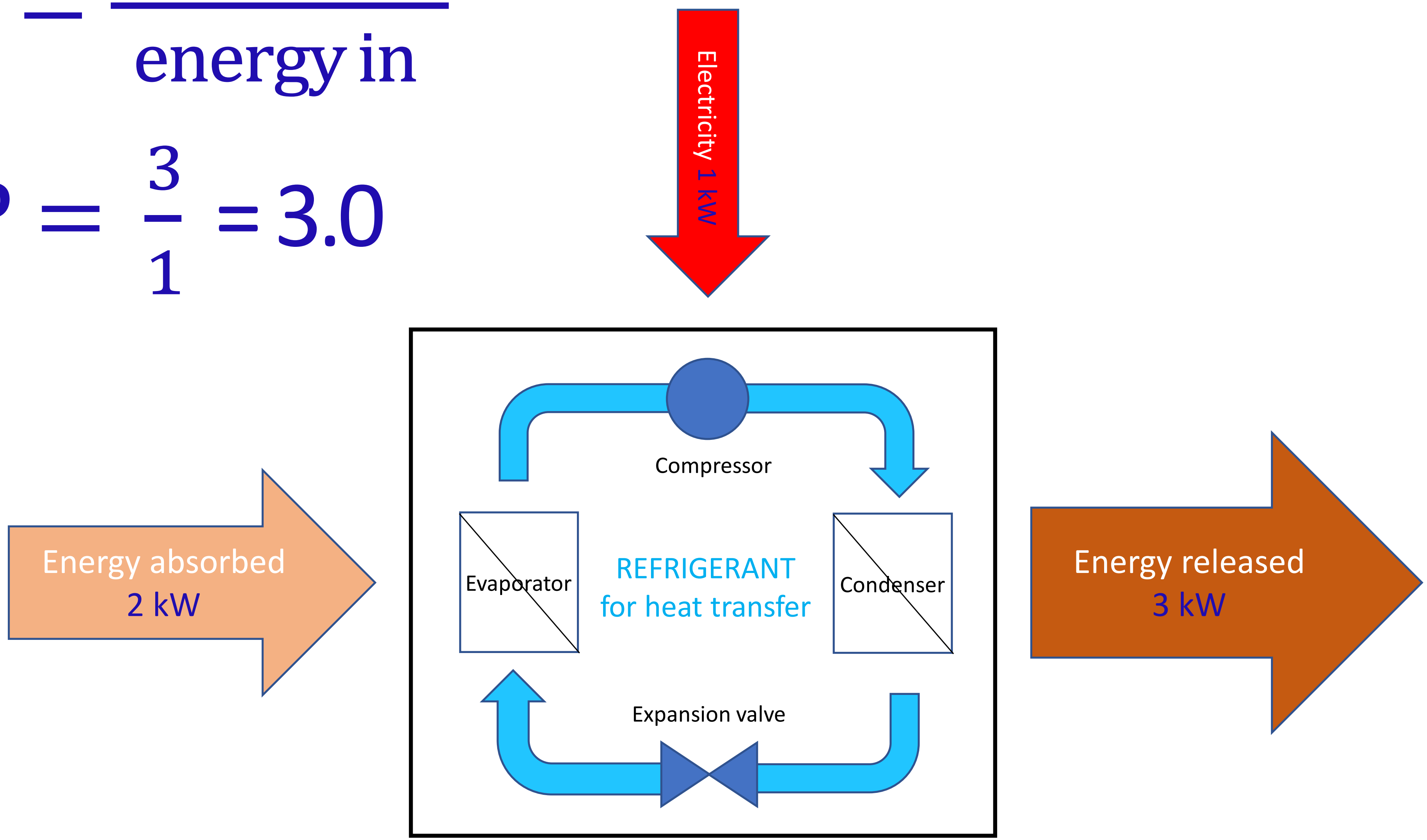

Energy released


EVAPORATION
CONDENSATION
Electricity for compressor
GAS
GAS
-5°C
40°C
Compressor
35°C
LTHW flow
AIR
REFRIGERANT
for heat transfer
WATER
30°C
LTHW return
Expansion valve
7°C outdoor
temperature
-5°C
35°C
LIQUID + GAS
LIQUID

Airflow: 22,000 $m^3/h$

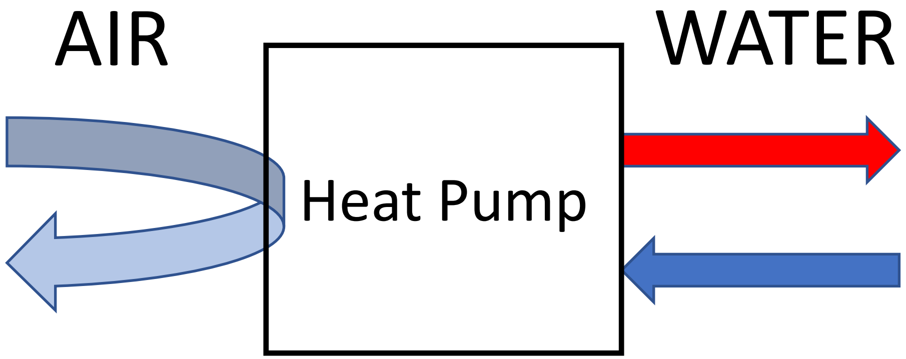
$$\mathrm{COP} = \frac{\text{energy out}}{\text{energy in}}$$

$$\mathrm{COP} = \frac{3}{1} = 3.0$$



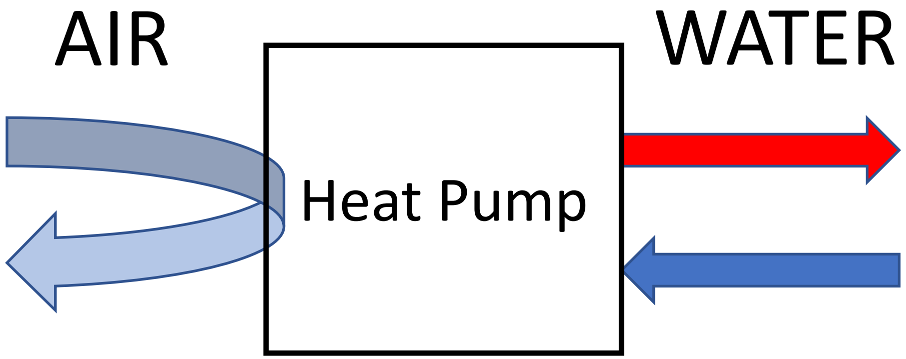
# COP – outdoor temperature

SAV



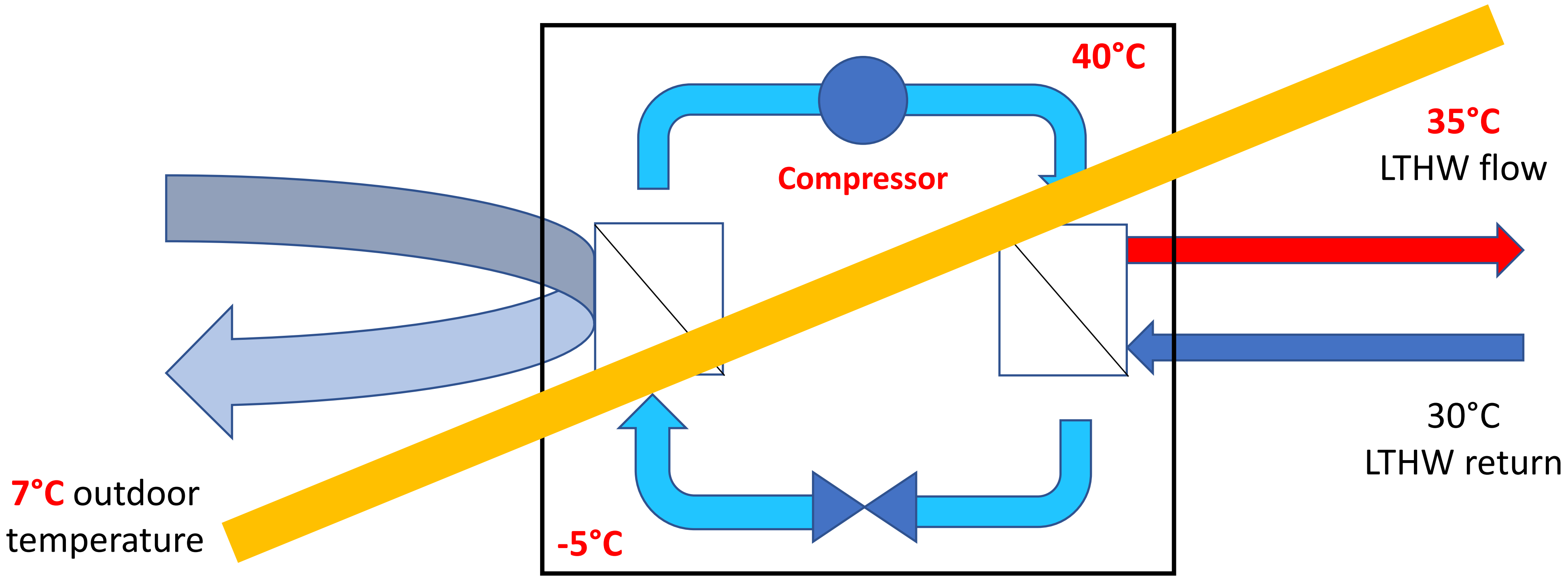

| Outdoor temp. | COP | HP operating temp. |
|---|---|---|
| 10°C | 4.58 | 30/35°C |
| 5°C | 3.63 | 30/35°C |
| 0°C | 2.90 | 30/35°C |

# COP – operating temperatures




| Outdoor temp. | COP | HP operating temp. |
|---|---|---|
| 5°C | 3.63 | 30/35°C |
| 5°C | 3.06 | 40/45°C |
| 5°C | 2.49 | 50/55°C |

# COP – temperature gap to bridge




COP decreases with increasing temperature difference

# Monetising return temperatures

## 43 kW HP

| Outdoor temp. | HP operating temp. | COP | Power input | Energy cost | | Emissions | |
|---|---|---|---|---|---|---|---|
| | | | | £/h | £/year | kg $CO_2$/h | kg $CO_2$/year |
| 5°C | 30/35°C | 3.63 | 12 kW | 1.6 | 6,400 | 6.2 | 24,800 |
| 5°C | 40/45°C | 3.06 | 14.2 kW | 1.9 | 7,600 | 7.4 | 29,600 |
| 5°C | 50/55°C | 2.49 | 17.5 kW | 2.3 | 9,200 | 9.1 | 36,400 |

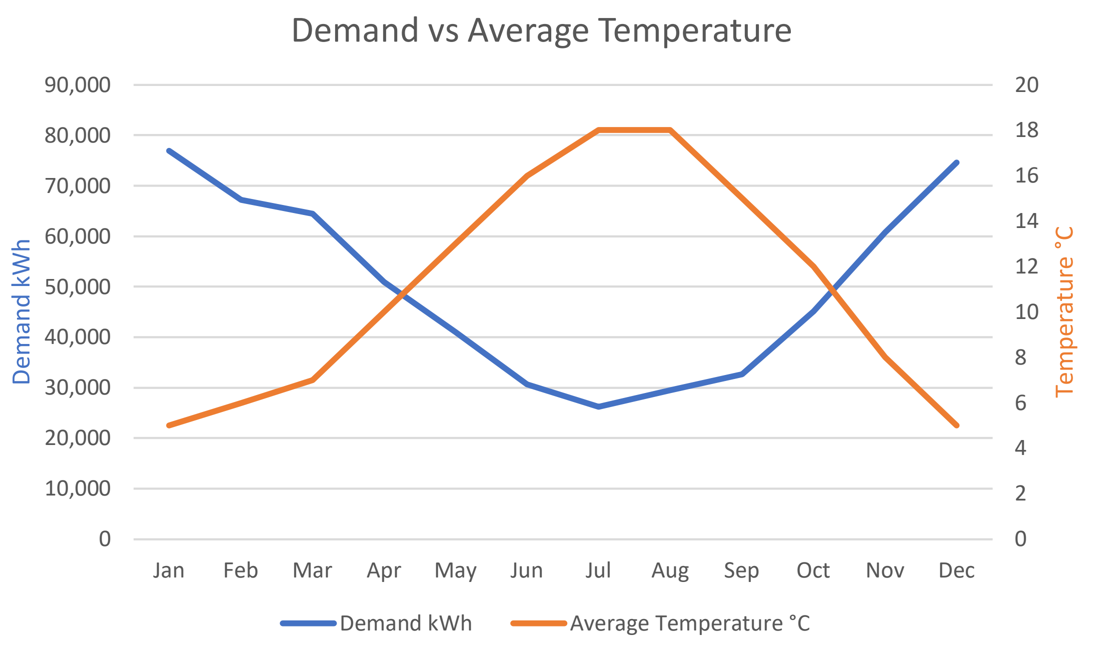
- Electricity price 13.19 p/kWh
- Electricity $CO_2$ 0.519 kg/kWh
- 4,000 operating hours per year

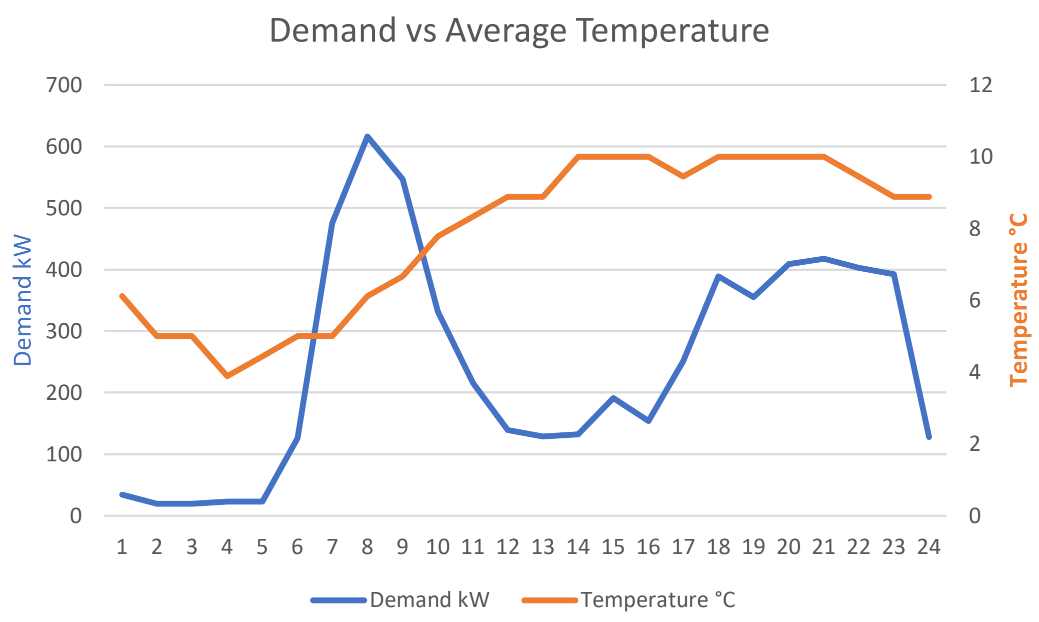
# COP – snapshot efficiency
# SCOP – seasonal COP

SCOP

- HP's average annual efficiency performance
- should be used in project assessment
- datasheet SCOP is based on 4,910 heating hours in Strasbourg
- ideally weather data from a project location should be used

# SCOP – seasonal COP




- seasonal temperatures and demand weighted
- should be at least 2.8

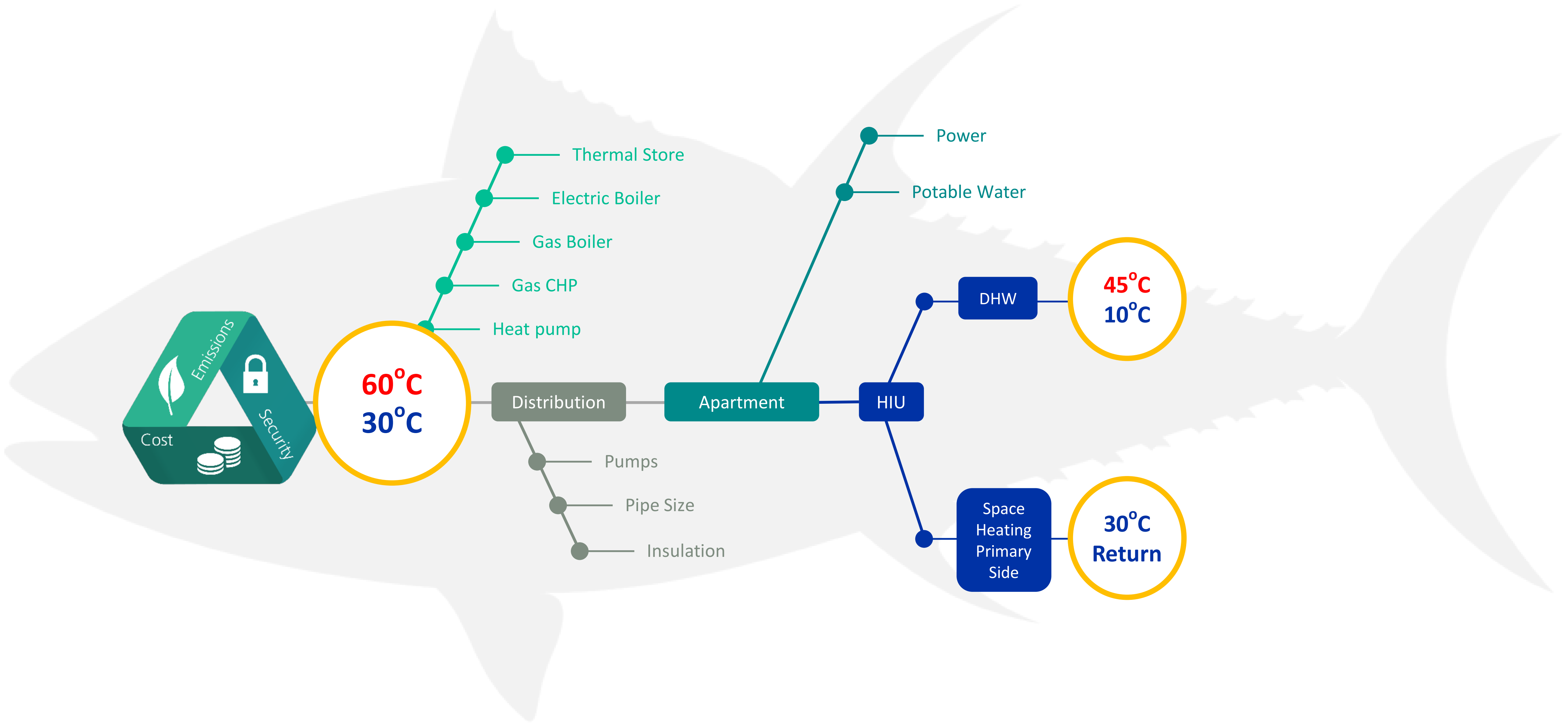
# Sizing – loads & diversity

| 150 two bedroom apartments | 60/30 |
|---|---|
| DHW load | 35 kW |
| Heating load | 2 kW |
| DHW diversity factor | 0.0756 |
| Heating diversity factor | 0.6225 |
| Peak plant without buffer | 584 kW |
| **Peak plant with buffer** | **256 kW** |
| DHW buffer volume | 2,000 l |
| **DHW peak flow rate** | **2.2 l/s** |
| **Heating peak flow rate** | **1.6 l/s** |
| **Total peak flow rate** | **3.8 l/s** |
| Plantroom pipe size | 65 mm |

| Design temperatures | | DHW | Heating |
|---|---|---|---|
| Heat Network (Primary) | Supply | 60°C | 60°C |
| | Return | 17°C | 32°C |
| Apartment (Secondary) | Supply | 45°C | 50°C |
| | Return | 10°C | 30°C |

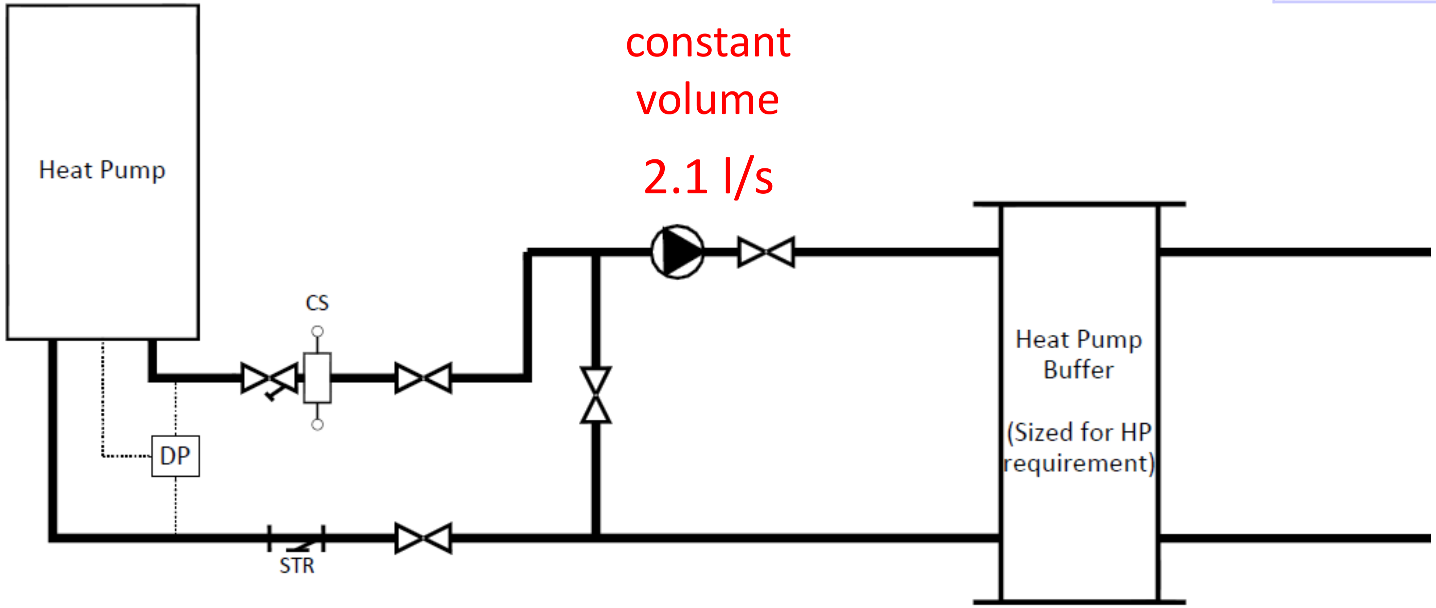
1) Heating and DHW diversity factors – CIBSE CP 1 2020 (expected to be published soon)

# Heat Network - Fishbone Diagram

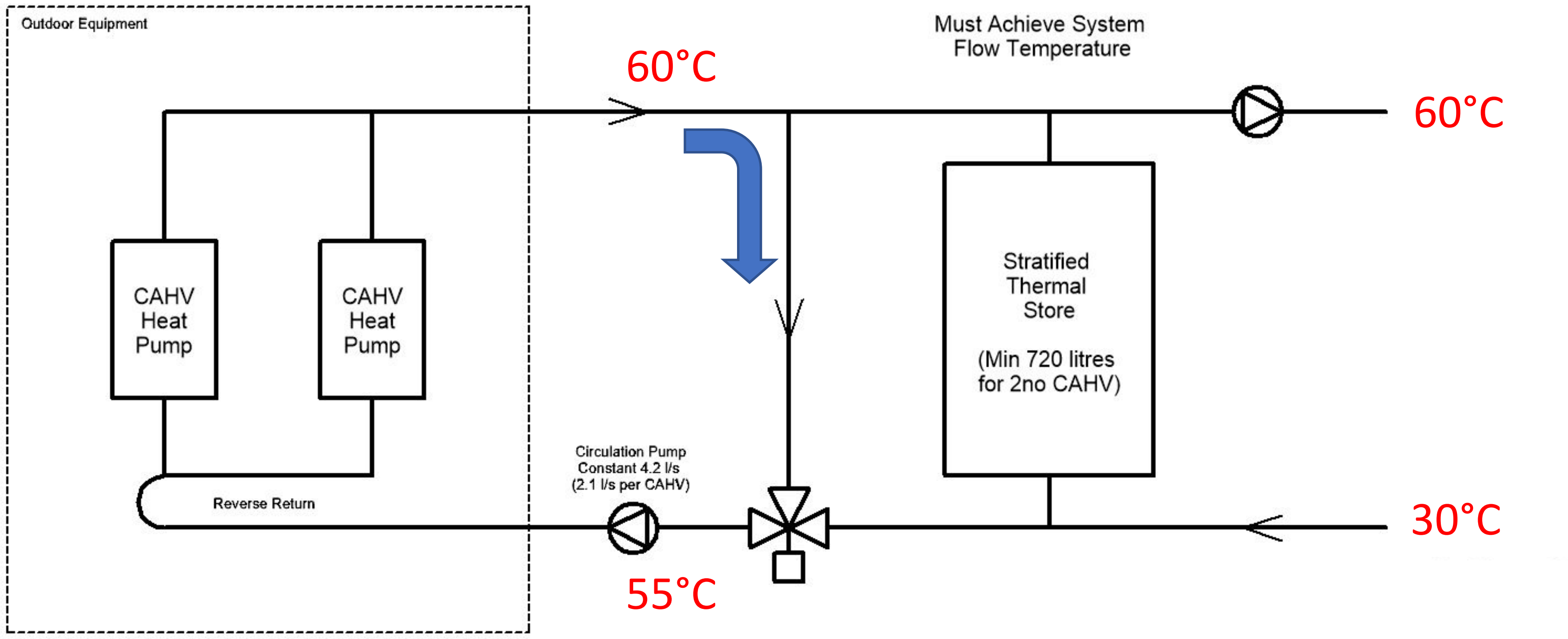


# Heat pump buffer and COP

| 150 two bedroom apartments | 60/30 |
|---|---|
| **DHW peak flow rate** | **2.2 l/s** |
| **Heating peak flow rate** | **1.6 l/s** |
| **Total peak flow rate** | **3.8 l/s** |



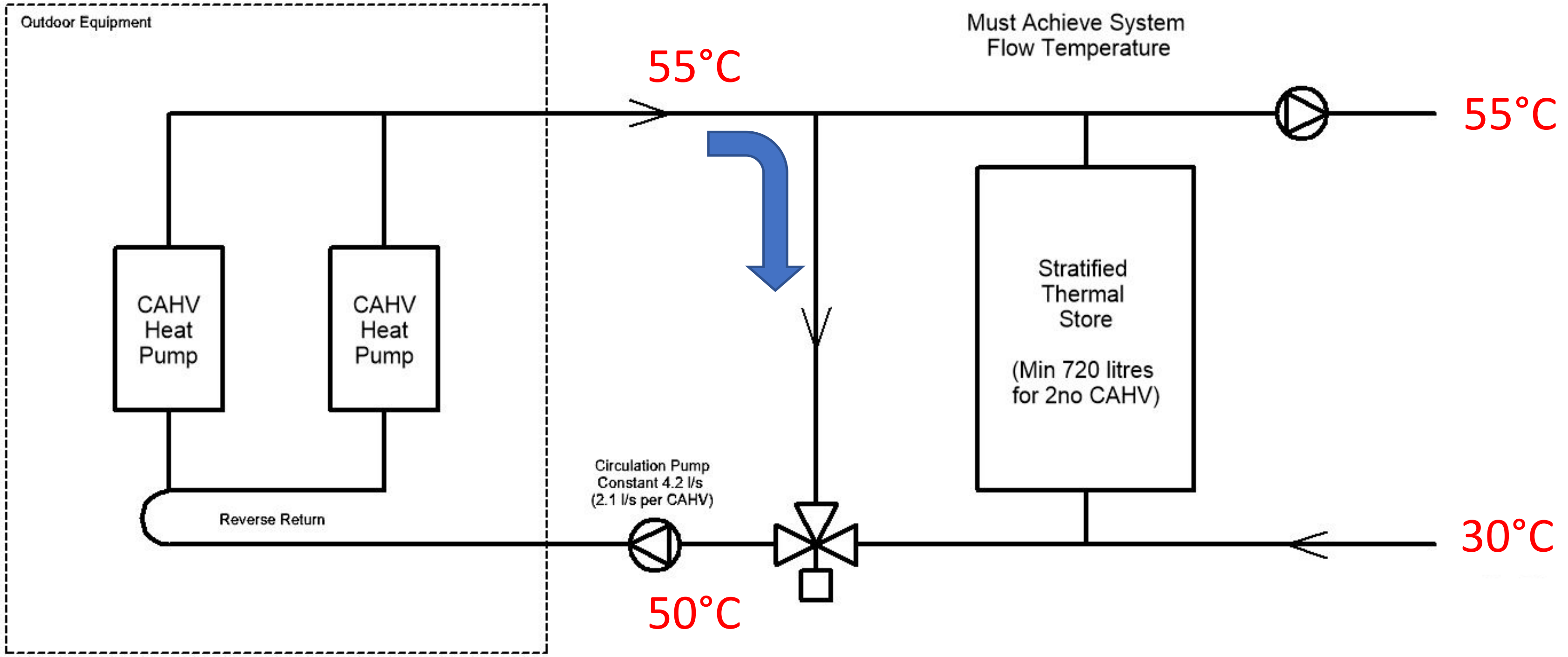
# Heat pumps only design




- must achieve system flow temperature
- poor COP (heat pump operating 55/60°C)
- SCOP below 2.8

| Outdoor temp. | COP | HP operating temp. |
|---|---|---|
| 5°C | 2.29 | 55/60°C |

# Heat pumps only design

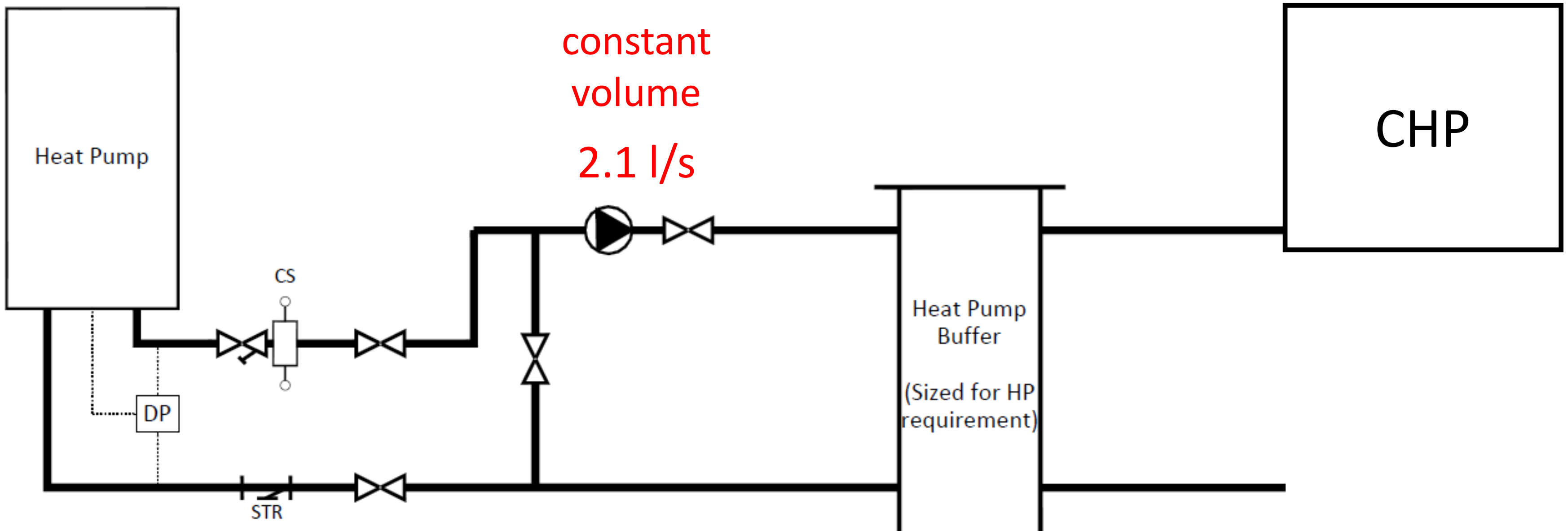



- must achieve system flow temperature
- poor COP (heat pump operating 50/55°C)
- SCOP below 2.8

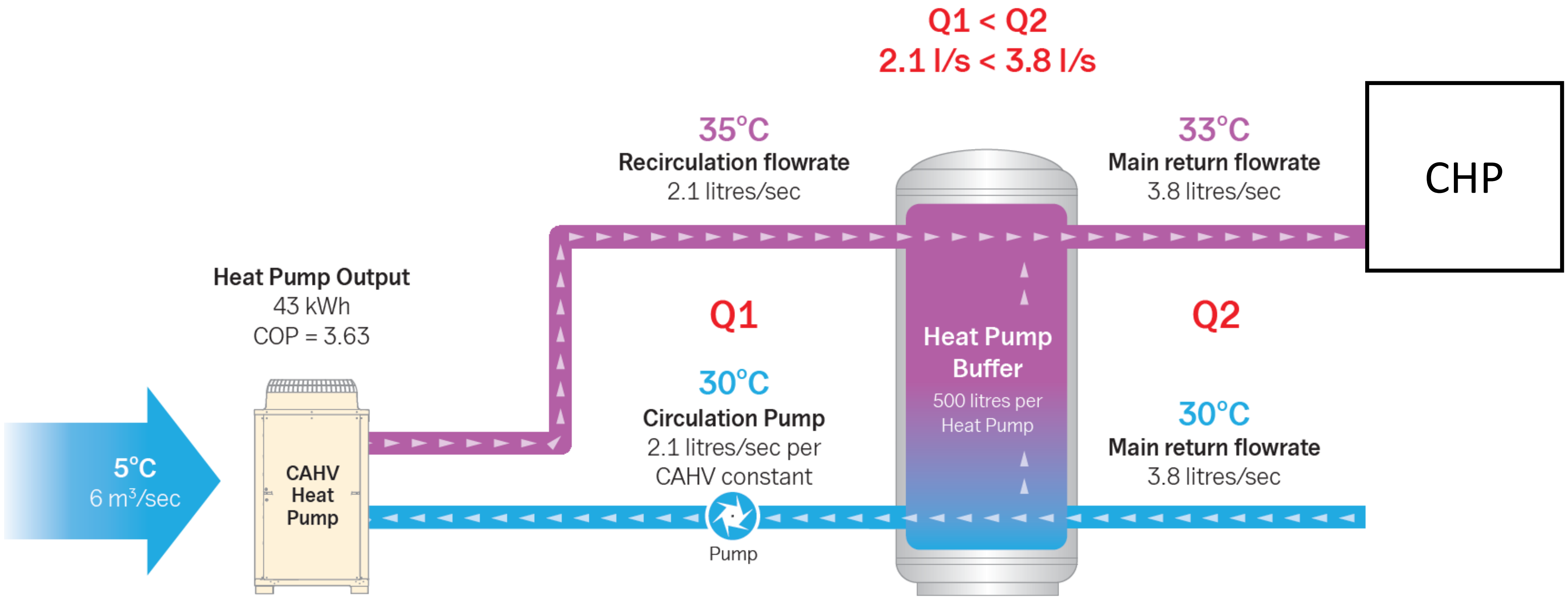
| Outdoor temp. | COP | HP operating temp. |
|---|---|---|
| 5°C | 2.49 | 50/55°C |

# Heat pump as preheat - buffer and COP

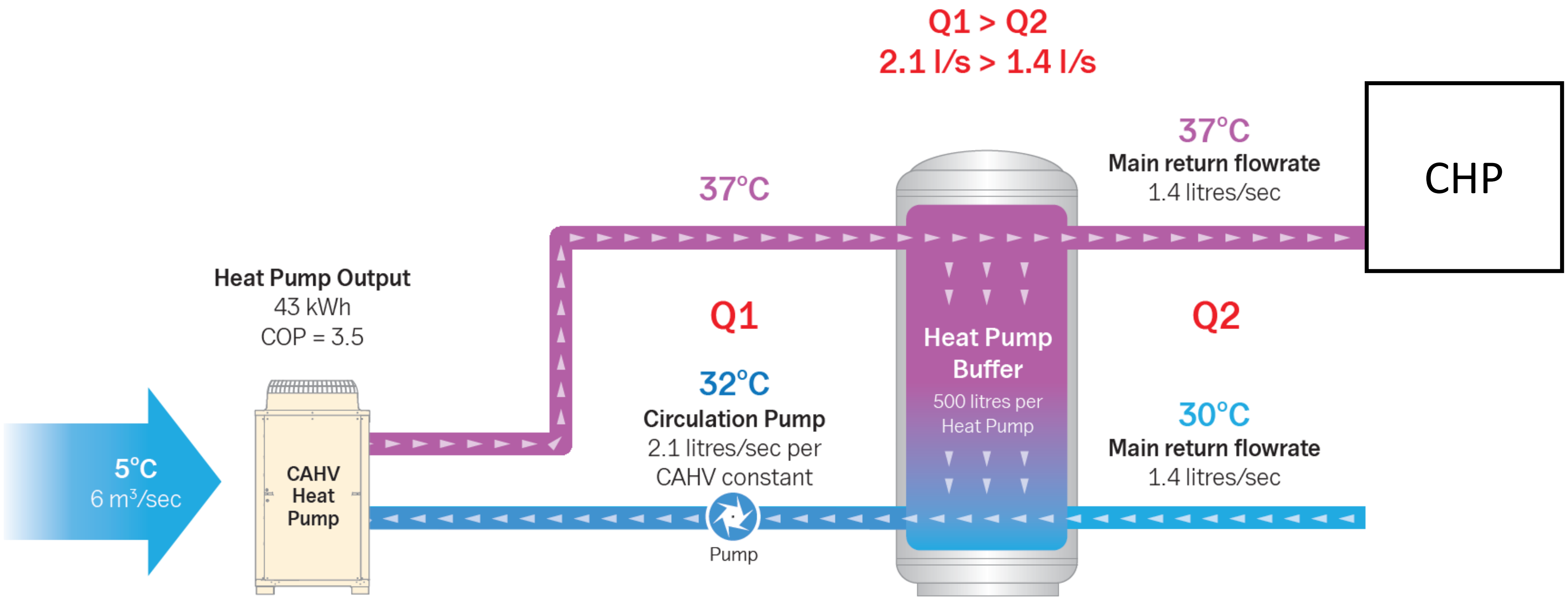
| | |
|---|---|
| 150 two bedroom apartments | 60/30 |
| DHW peak flow rate | 2.2 l/s |
| Heating peak flow rate | 1.6 l/s |
| Total peak flow rate | 3.8 l/s |



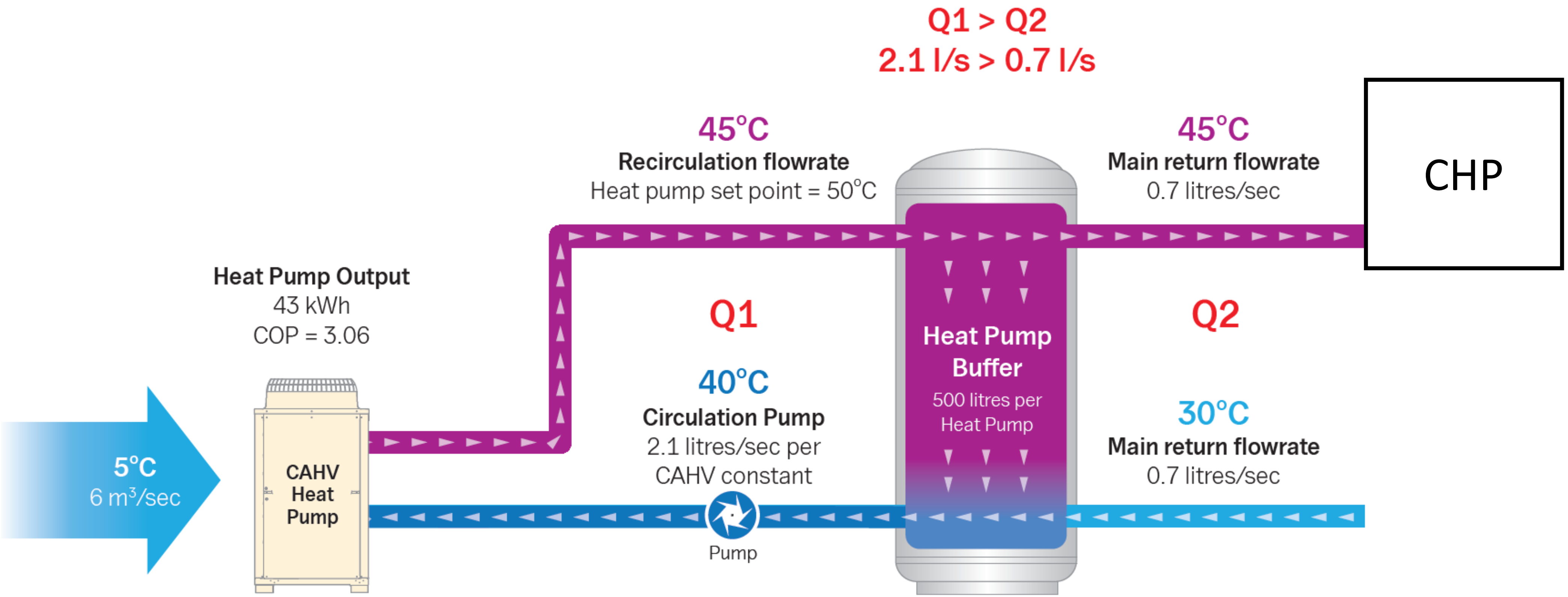
# Heat pump as preheat - buffer and COP



# Heat pump as preheat - buffer and COP



# Heat pump as preheat - buffer and COP



# Plant selection (150 flats) - cost

## HP only plant room

| Type of plant | Max. thermal output | Thermal store/buffer | Capital cost | Cost per flat |
|---|---|---|---|---|
| Heat pumps (CAHV) | 6 x 43 kW | 2,200 l | £22,700 each | |
| **Total** | **258 kW** | **2,200 l** | **£136,000** | **£907** |

## Hybrid plant room

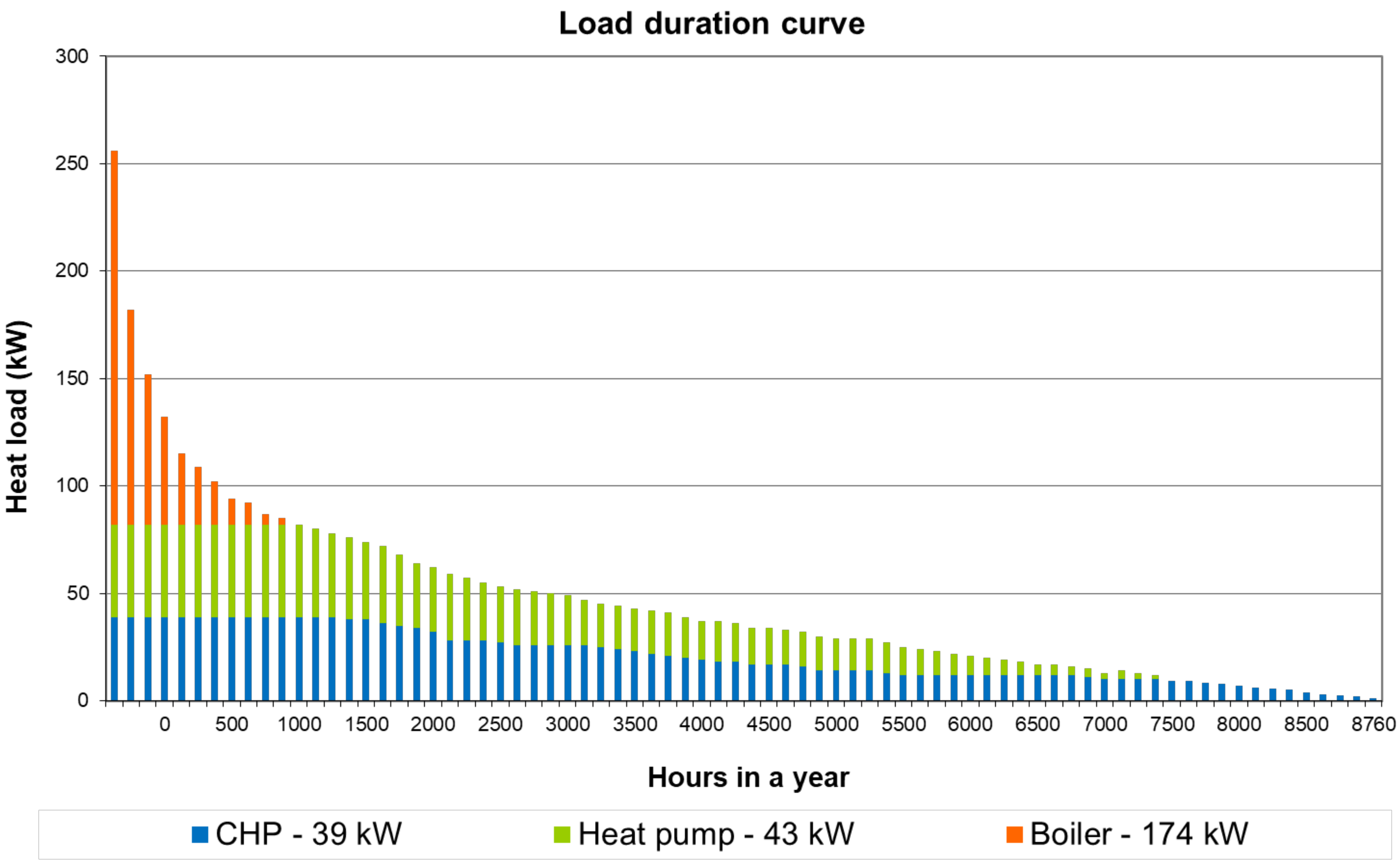
| Type of plant | Max. thermal output | Thermal store/buffer | Capital cost | Cost per flat |
|---|---|---|---|---|
| CHP (XRGI 20) | 39 kW | 500 l | £42,000 | |
| Heat pump (CAHV) | 43 kW | 500 l | £23,000 | |
| Boiler (gas or electric) | 174 kW | 2,000 l | £16,000 | |
| **Total** | **256 kW** | **3,000 l** | **£81,000** | **£540** |

# Design choices

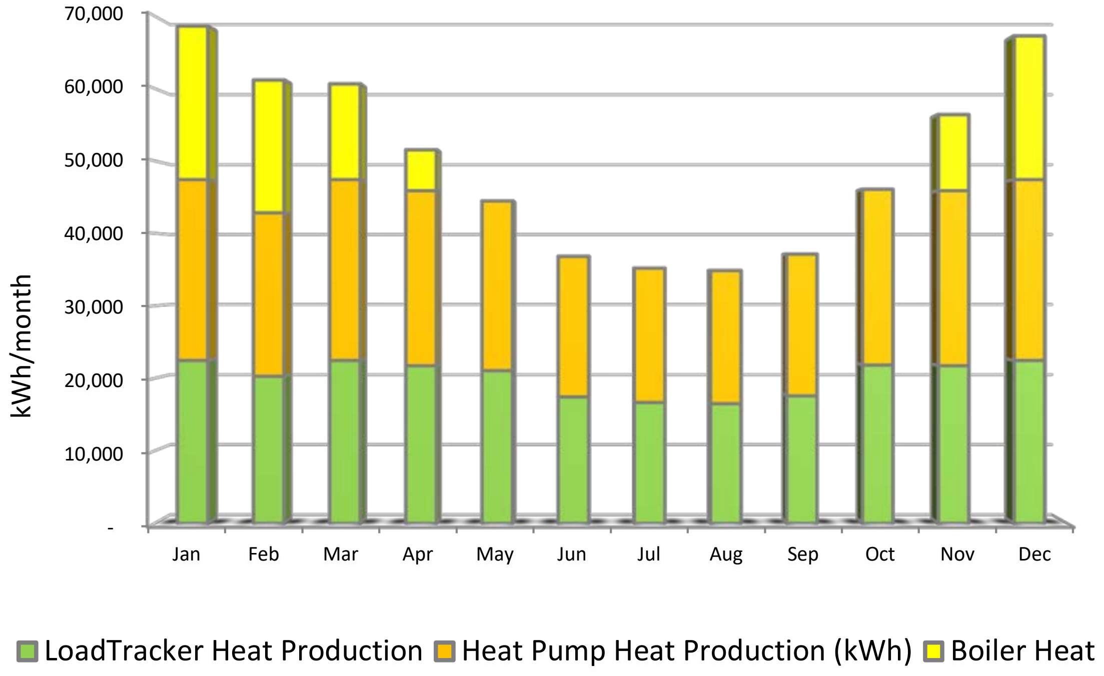
| | HP only | HP + CHP + boiler |
|---|---|---|
| CAPEX | £136,000 | £81,000 |
| OPEX | £42,000 | £25,000 |
| SCOP | 2.5 | 3.2 |
| Security of supply | x | v |
| Sector coupling | x | v |
| SAP 2012 / el. grid marginal | | |
| $CO_2$ (tonnes/year) | 163 | 131 |
| $CO_2$ reduction | 15% | 31% |
| SAP 10 (used by GLA) | | |
| $CO_2$ (tonnes/year) | 73 | 118 |
| $CO_2$ reduction | 56% | 29% |

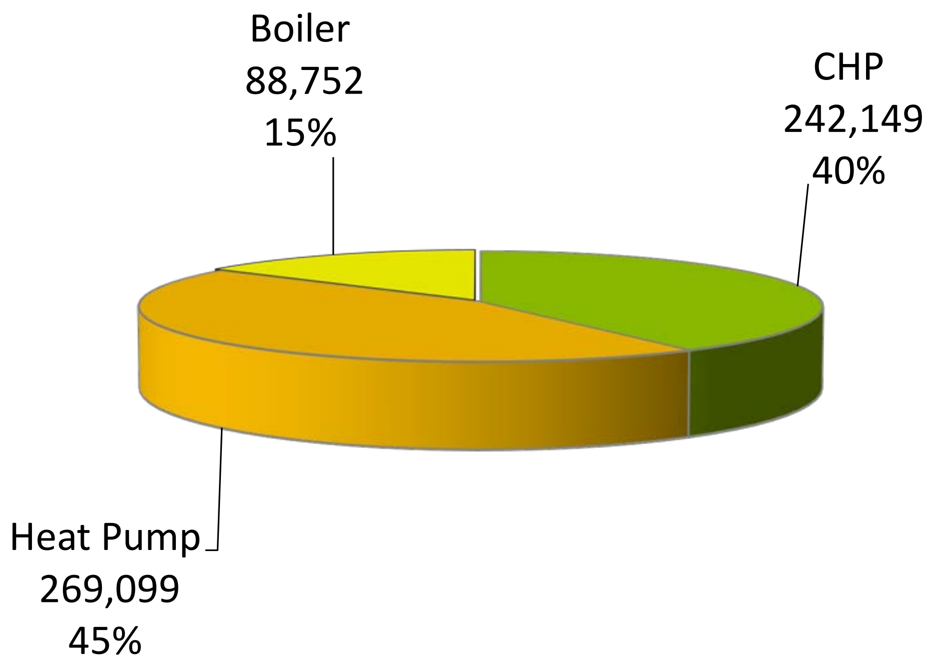
El. 13.19 p/kWh
Gas 3.94 p/kWh

# Plant selection – peak capacity



# Plant selection – 150 apartments



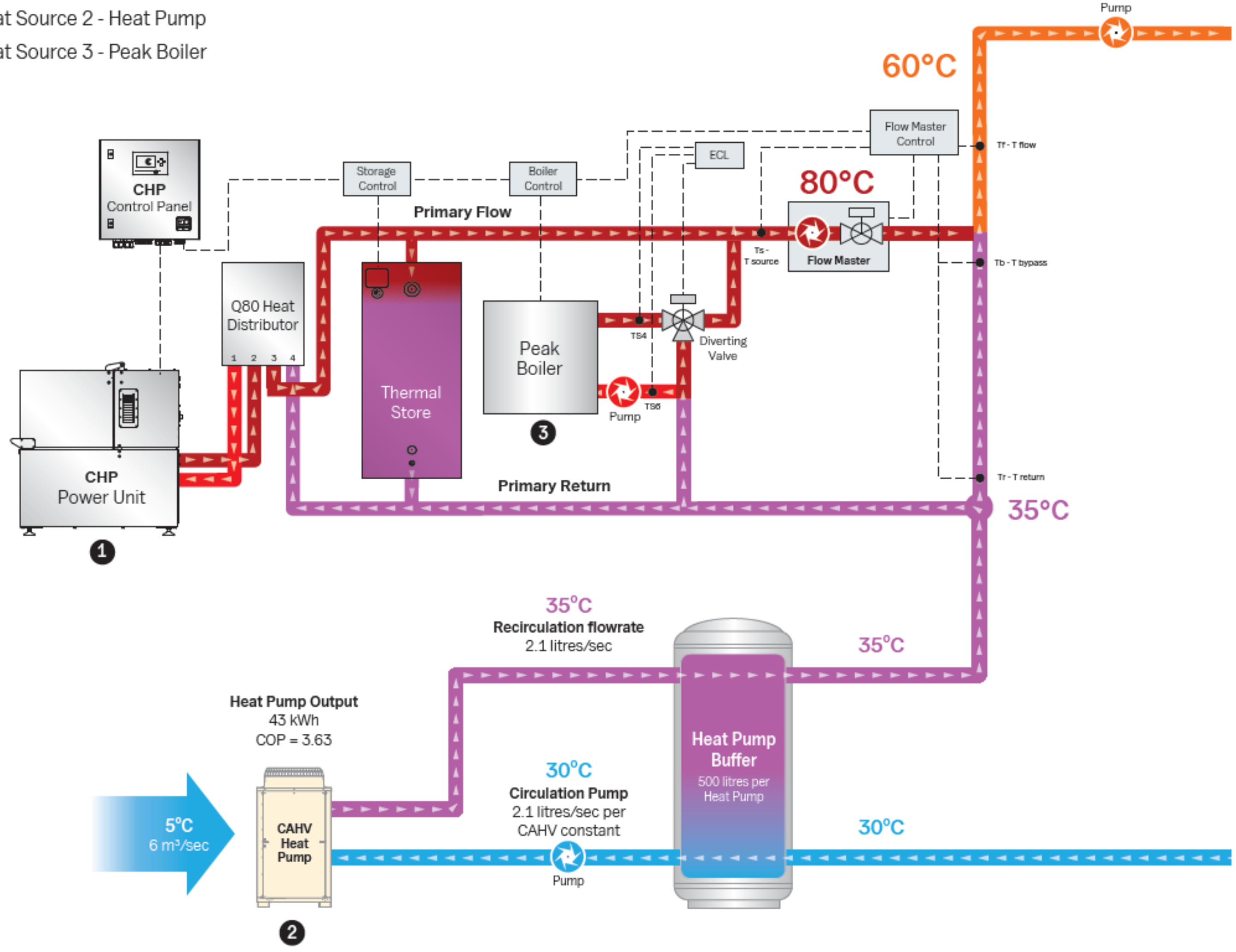




- 150 apartments
- annual DHW and heating demand 600,000 kWh
- annual electricity demand 75,000 kWh

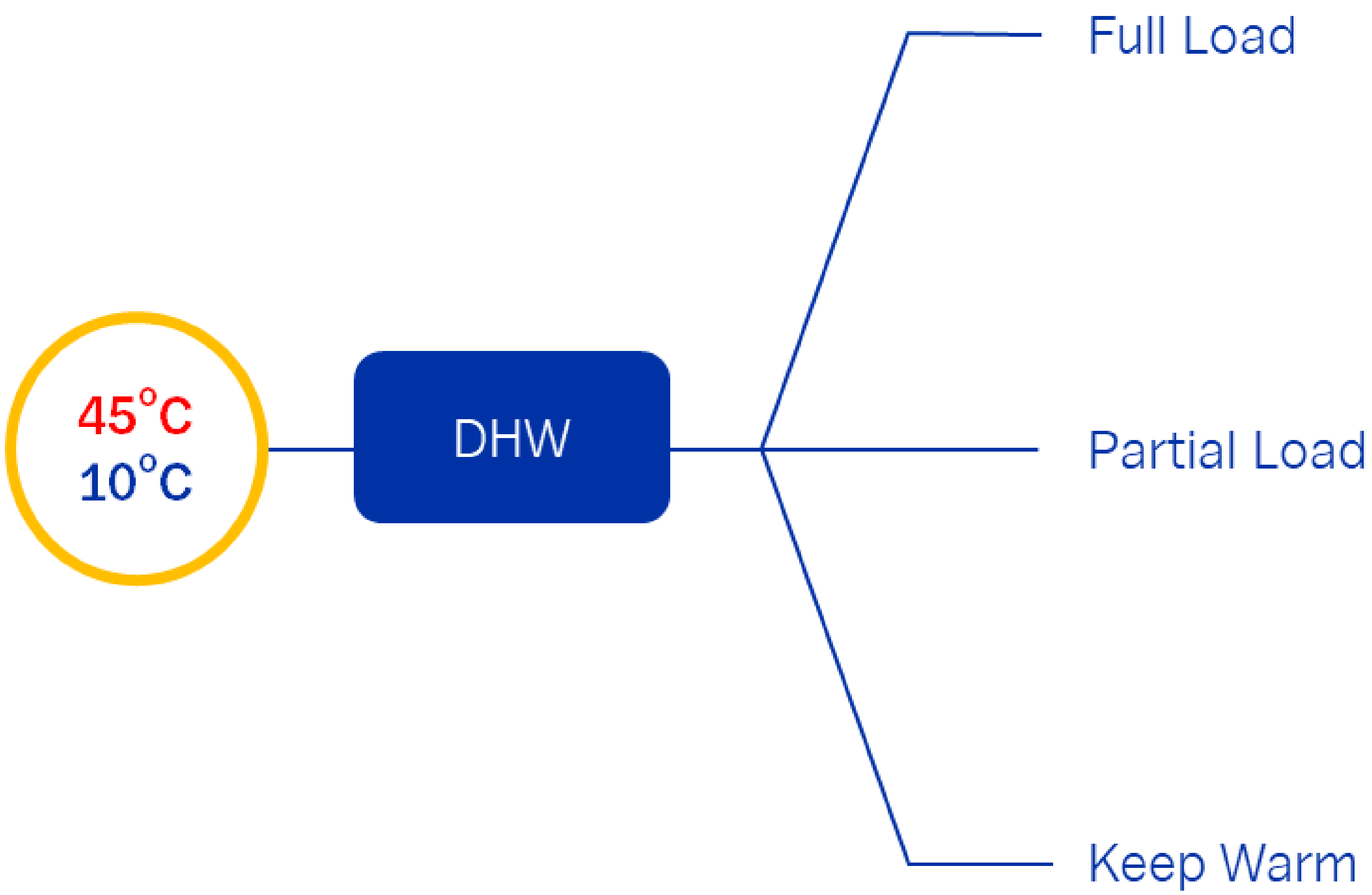
# HP + CHP + boiler parallel design

**High Load (100%)**
Heat Source 1, 2 & 3

1. Heat Source 1 - CHP
2. Heat Source 2 - Heat Pump
3. Heat Source 3 - Peak Boiler



# Heat Network – DHW



SAV

50°C
10°C

# Return temperatures - 35kW DHW

| Cold water temperature °C | 10° | 15° | 20° |
|---|---|---|---|
| Primary temperature °C | Return temperature °C | Return temperature °C | Return temperature °C |
| 60°C | 19.97°C | 23.25°C | 26.7°C |

45°C
10°C

# Return temperatures - 35kW DHW

| Cold water temperature °C | 10° | 15° | 20° |
|---|---|---|---|
| Primary temperature °C | Return temperature °C | Return temperature °C | Return temperature °C |
| 60°C | 16.64°C | 20.12°C | 23.9°C |

# DHW Tapping Temperature – UK Clarification

■ HEATING, WATER HEATERS AND DATA CENTRES

**SPECIAL FEATURES**

This month: Water heater news; Rinnai updates on hydrogen appliances; Li-ion batteries in data centres

**HSE clarifies risk guidance on instantaneous water heaters**

DHW energy efficiency consultation to take place this month

The requirement for ≥50°C delivery at outlets in M1 minute is applicable to systems incorporating hot-water storage, and does not necessarily apply for instantaneous water heaters. This means that the HSE has no fundamental objection to the reduction in temperature at outlets from HIUs.

- **No Stored water (low risk)**
- **HIU = Combi boilers accepted temperatures**
- **Dish washing 45  sufficient**

Response from Proctor & Gamble's R&D department:

*"We test Fairy across a range of temperatures. However, 38-41 ℃ is in the normal temperature range that a consumer would use for this product."*

CIBSE Journal April 2020/Fairheat & Aecom Seminar What to do about hot water 3rd December 2019

# DHW – Load Revision - UK

## CP 1 (2020)

Table 10 - Typical sizes of DHW HIU plate heat exchangers

| Property type/suitability | Design Maximum occupancy | Number of bathrooms | Typical maximum power @ 10°C feed and 55°C DHW supply temperatures |
|---|---|---|---|
| Studio/1-bed | 1 | 1 | 25-30 kW |
| Large 1-bed/ Small 2-bed | 3 | 1 | 30-35 kW |
| Medium 2-bed/3-bed | 4 | 2 | 35 kW |

# Space Heating

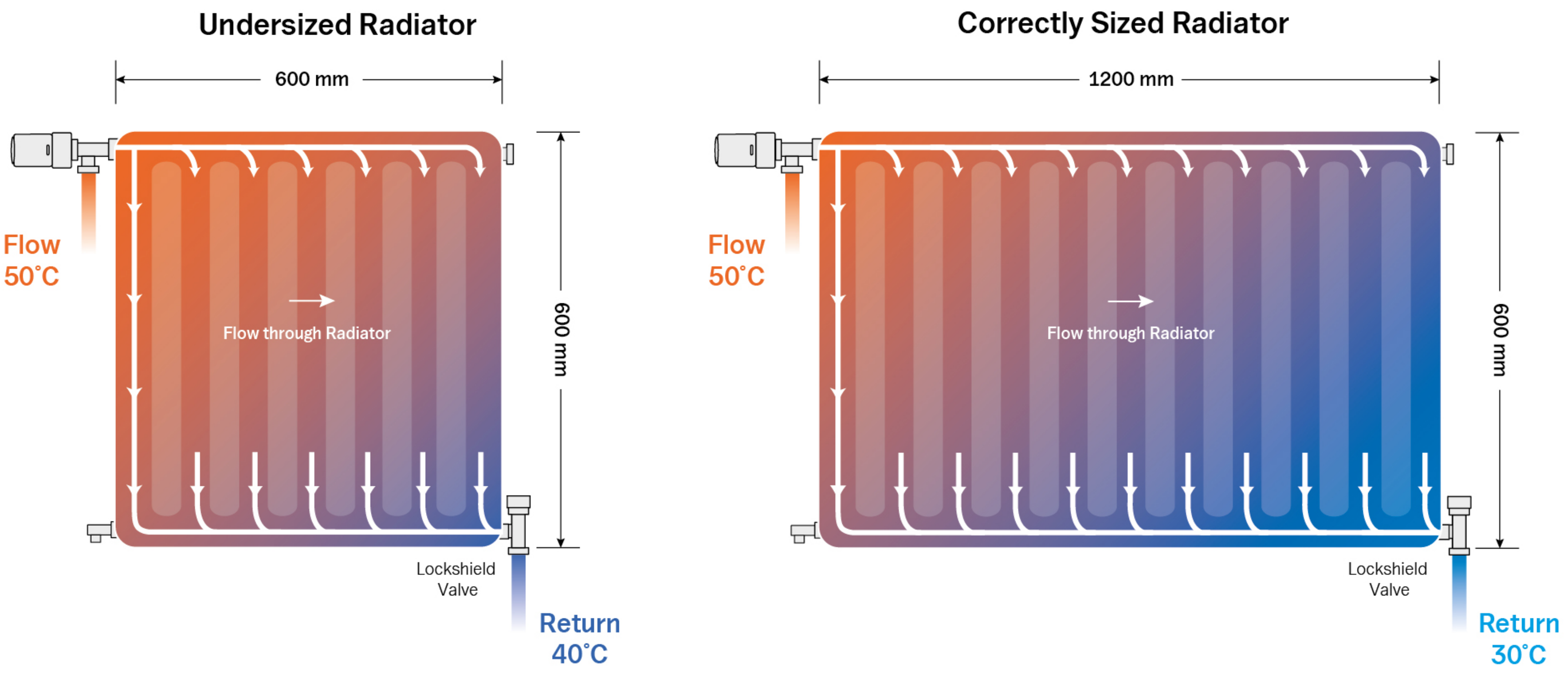

## Best practice – typically not more than 25 $W/m^2$

**Space heating selection is critical for achieving low system return temperatures and efficient plant and distribution infrastructure sizing.**

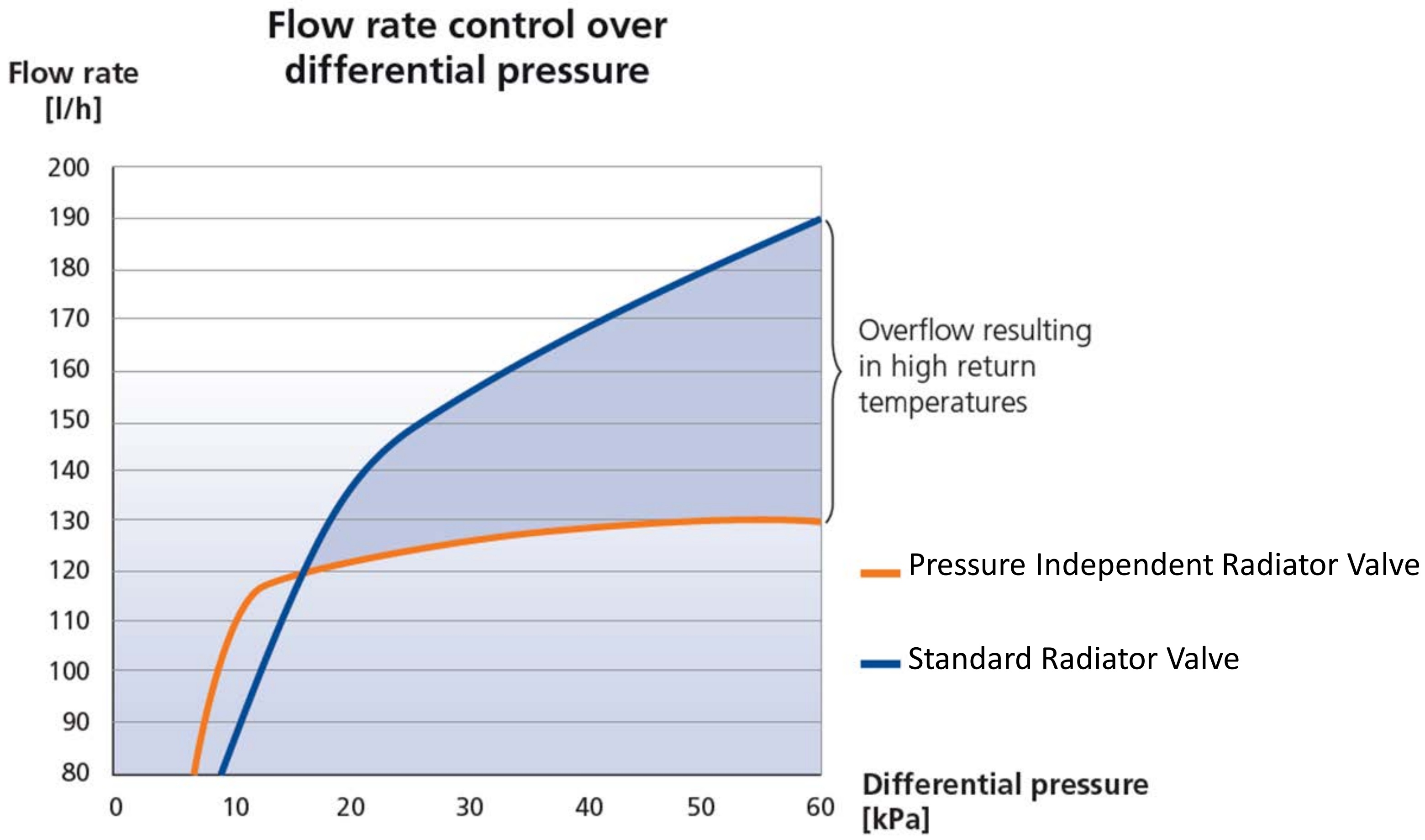
# Radiator Heating

| Heat Network return temperature Target - 30 °C | | |
|---|---|---|
| | | |
| Heat Network return | Space heating flow | Space heating return |
| 38.31°C | 55°C | 35°C |
| 31.81°C | 50°C | 30°C |

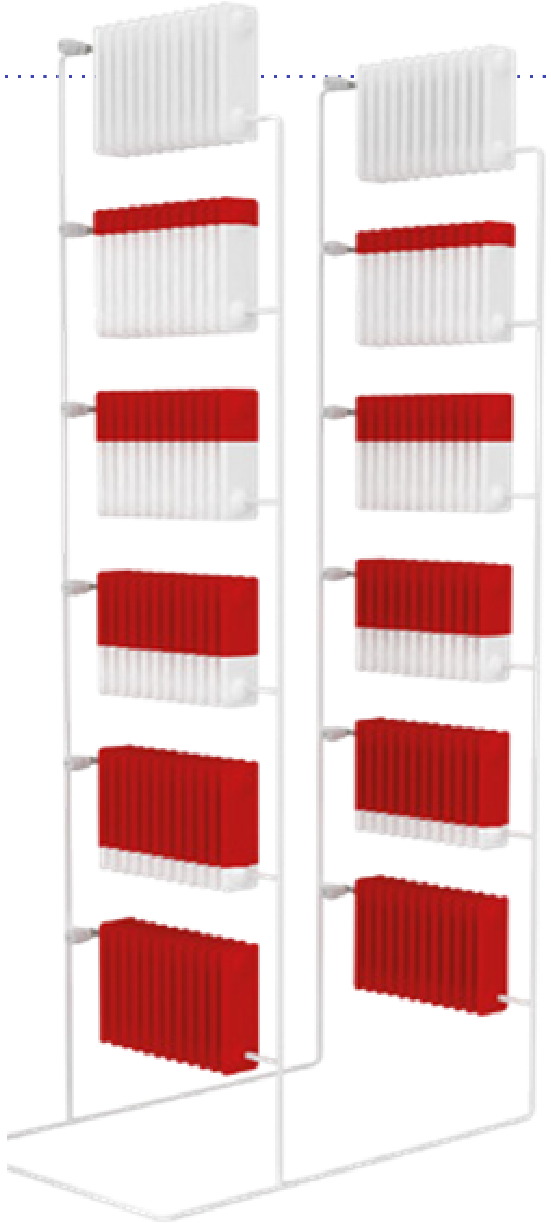
# Selection of Heat Emitters



# Pressure Independent Control Valve




* At setting N (fully open)



# Underfloor Heating

| Heat Network return temperature Target - 30 °C | | |
|---|---|---|
| | | |
| Heat Network return | Space heating flow | Space heating return |
| 35.08°C | 40°C | 35°C |
| 30.05°C | 35°C | 30°C |

# Heating - UFH

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- Avoid high thermal mass
- Avoid returns above 30°C

**Screeded Floors**

**UFH System Output (W/m²)**

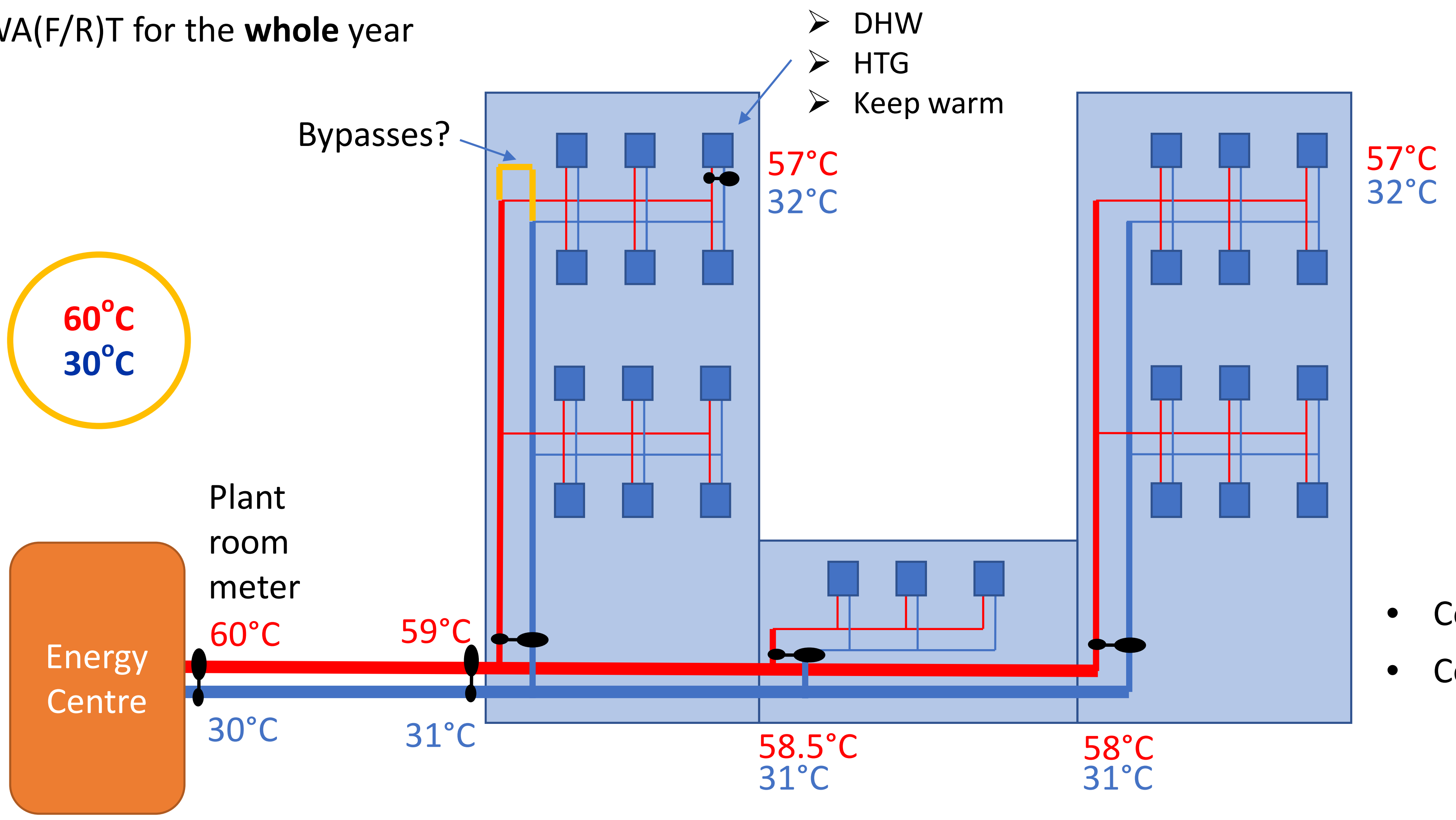
| Flow/Return Temperatures & UFH Pipe Centres (mm) | | | | | |
|---|---|---|---|---|---|
| 65-55°C | | 60-50°C | | 55-45°C | |
| 200mm | 300mm | 200mm | 300mm | 200mm | 300mm |

# Primary side

- Reduce pipe size (possible with new guidelines)
- Insulate to avoid gains and losses

# What Does 60/30 Scheme Look Like?

VWA(F/R)T for the **whole** year




- Communal areas
- Commercial area

# Ultrasonic Meter Commissioning

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Calculator

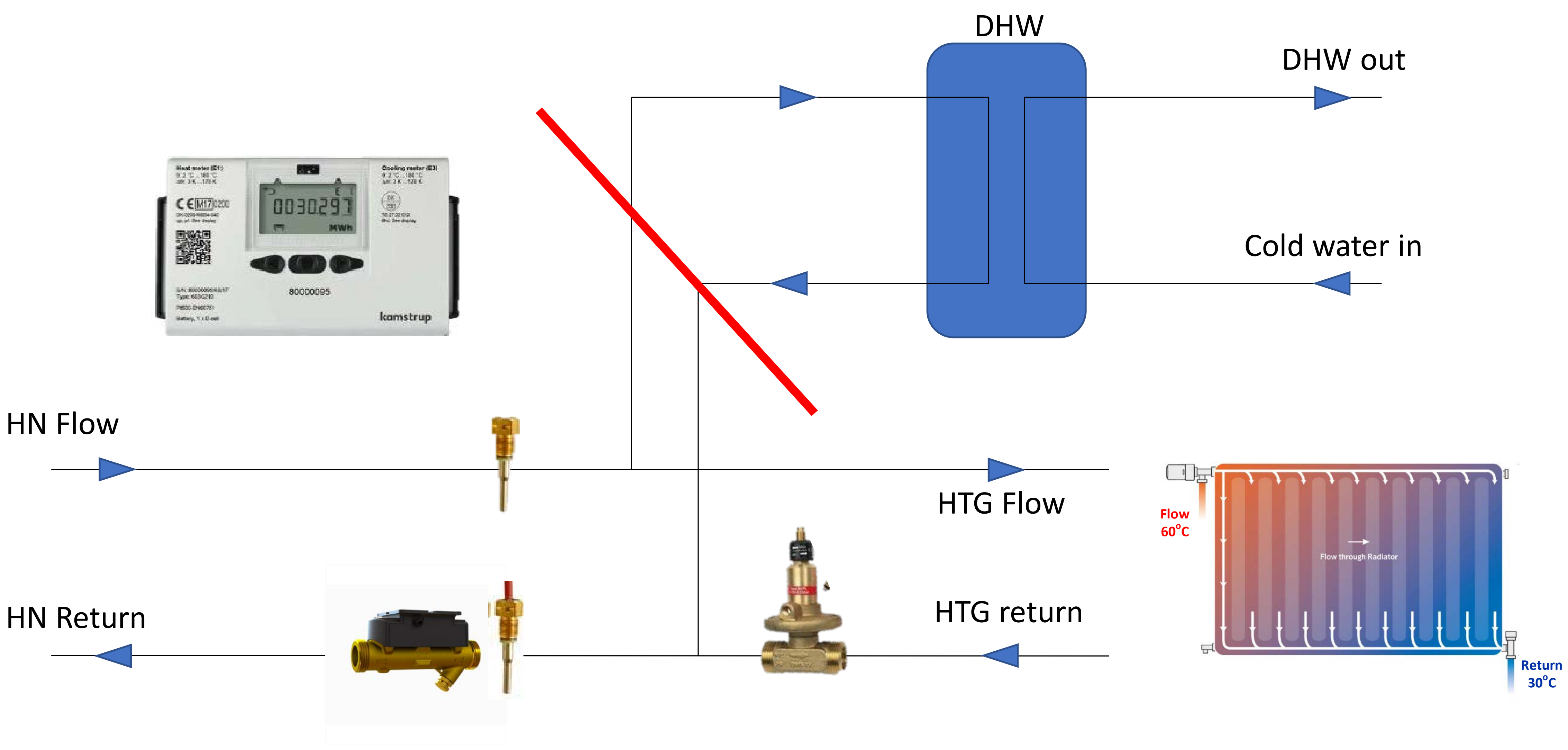

Ultrasonic
flow piece

Temperature
probes

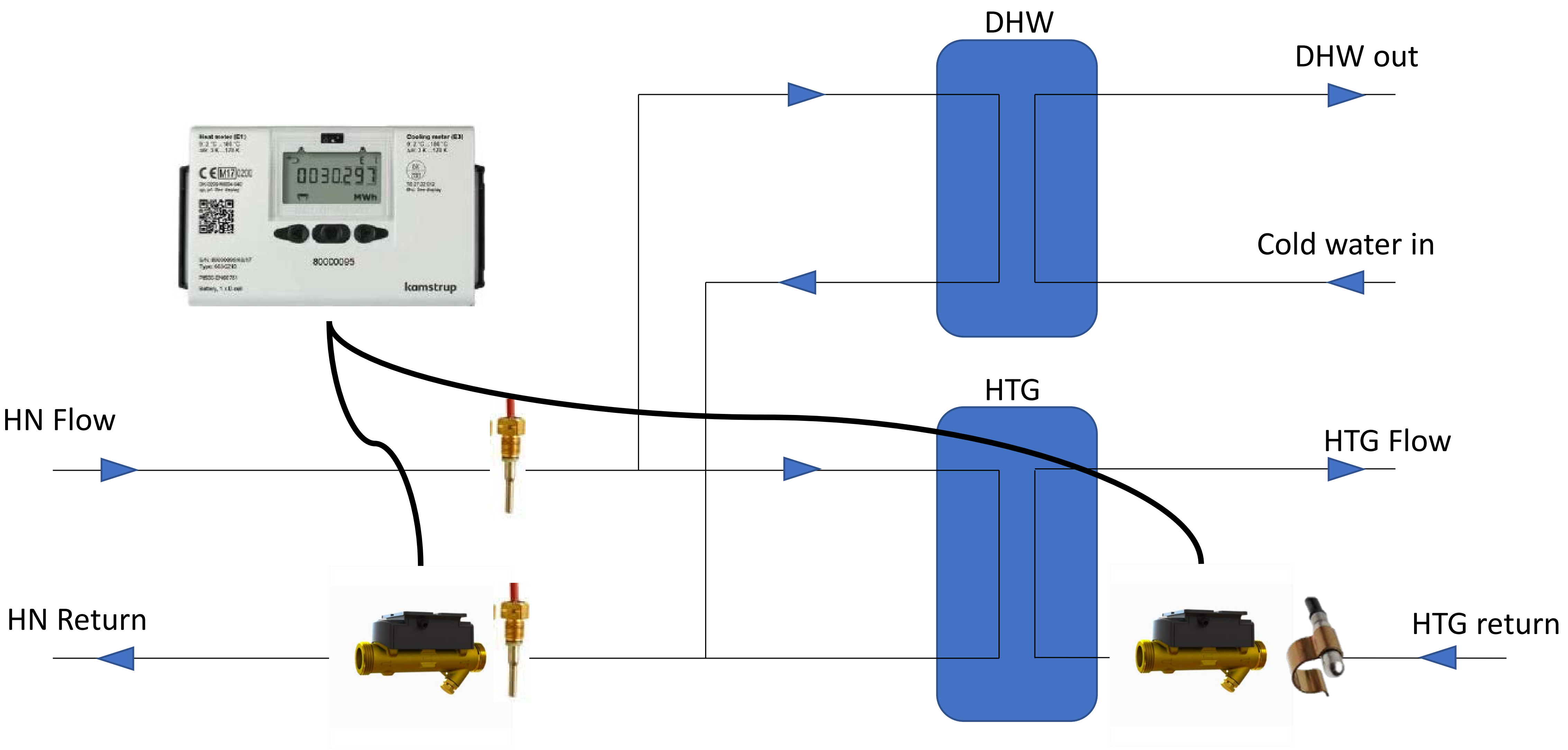
**Meter infrastructure for:**

- Billing
- Commissioning
- Monitoring

# Commissioning on Direct Units



# 60/30 Commissioning Method with UMS



# Commissioning Method with UMS

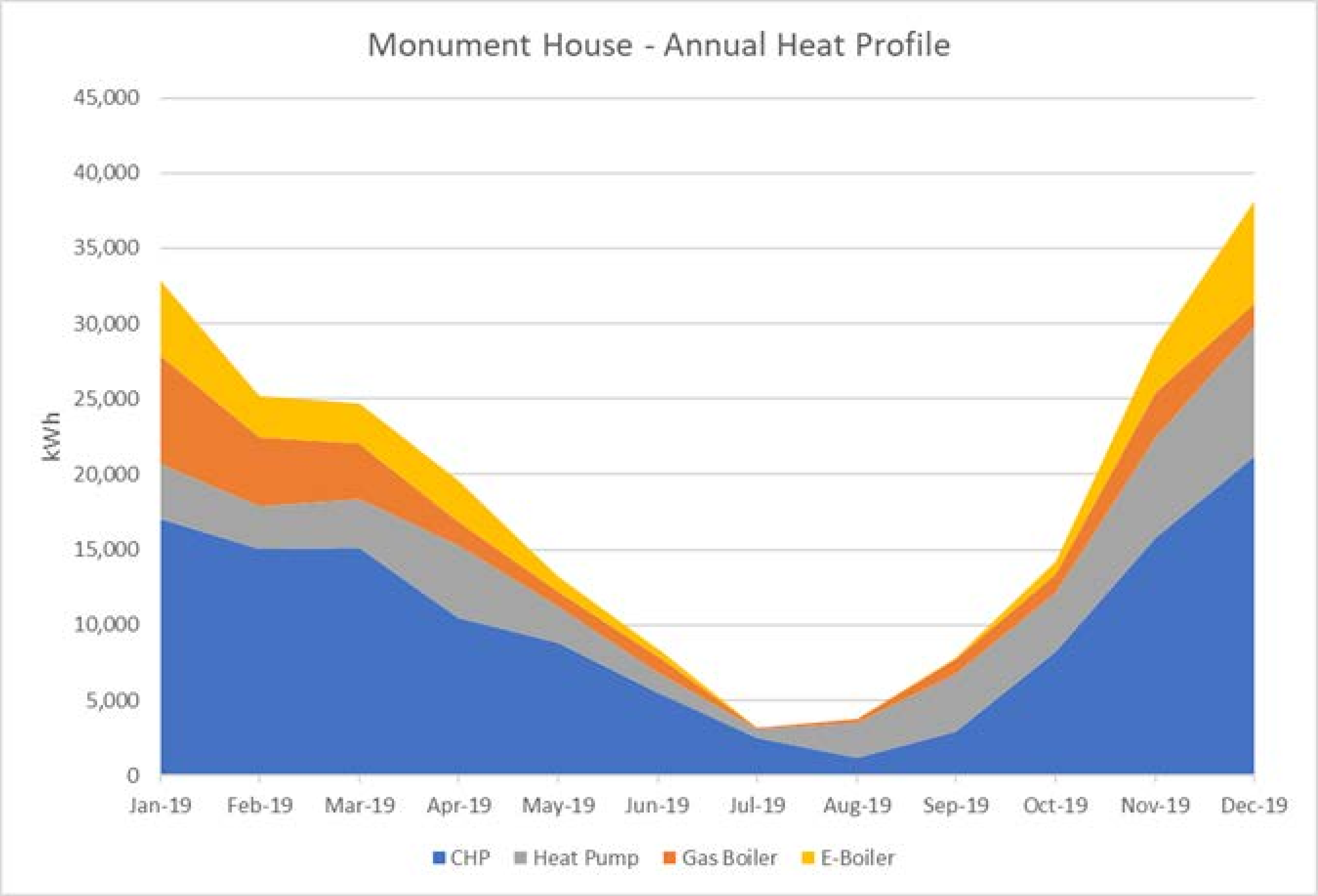
**Each heat emitter**

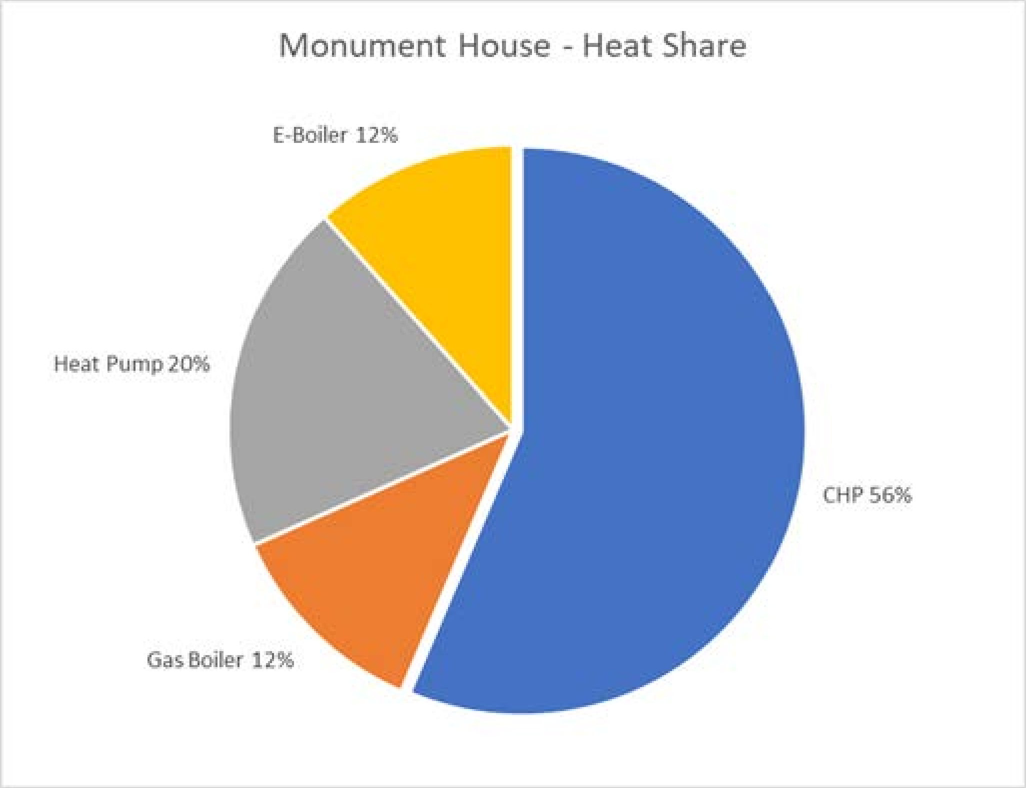
- Set the valve to the required setting
- The lock shield valve fully open
- Confirm the desired flow rate at the energy meter (adjust accordingly)
- Flow and return temps (may vary from design conditions)

**Full load**

- Confirm full load flow rate
- Flow and return temps (may vary from design conditions)

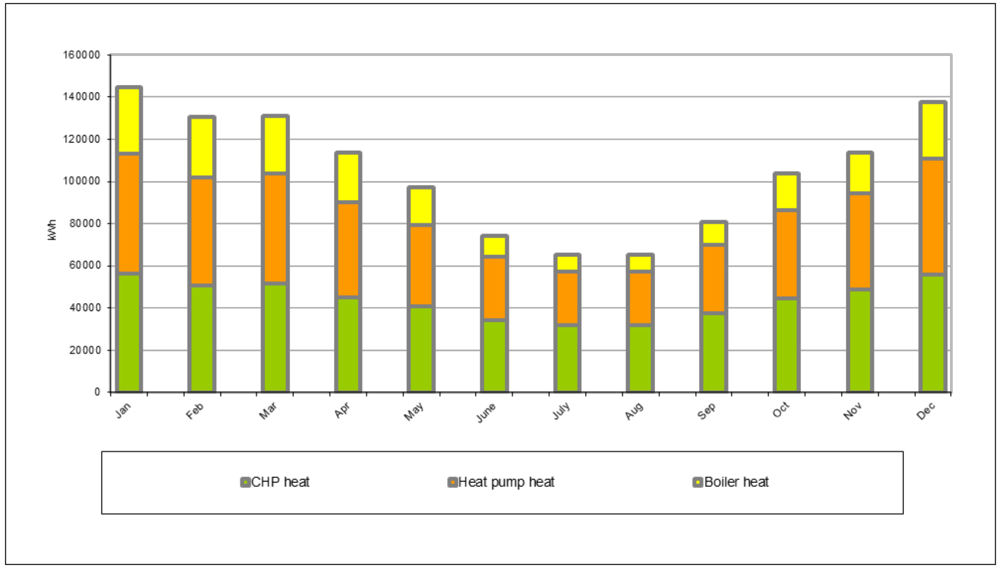
# SAV office and warehouse

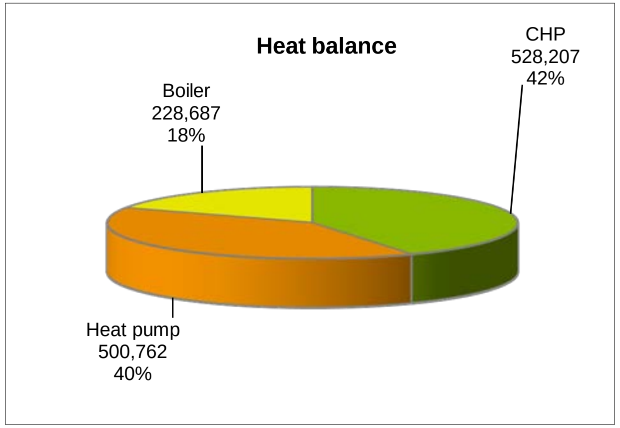


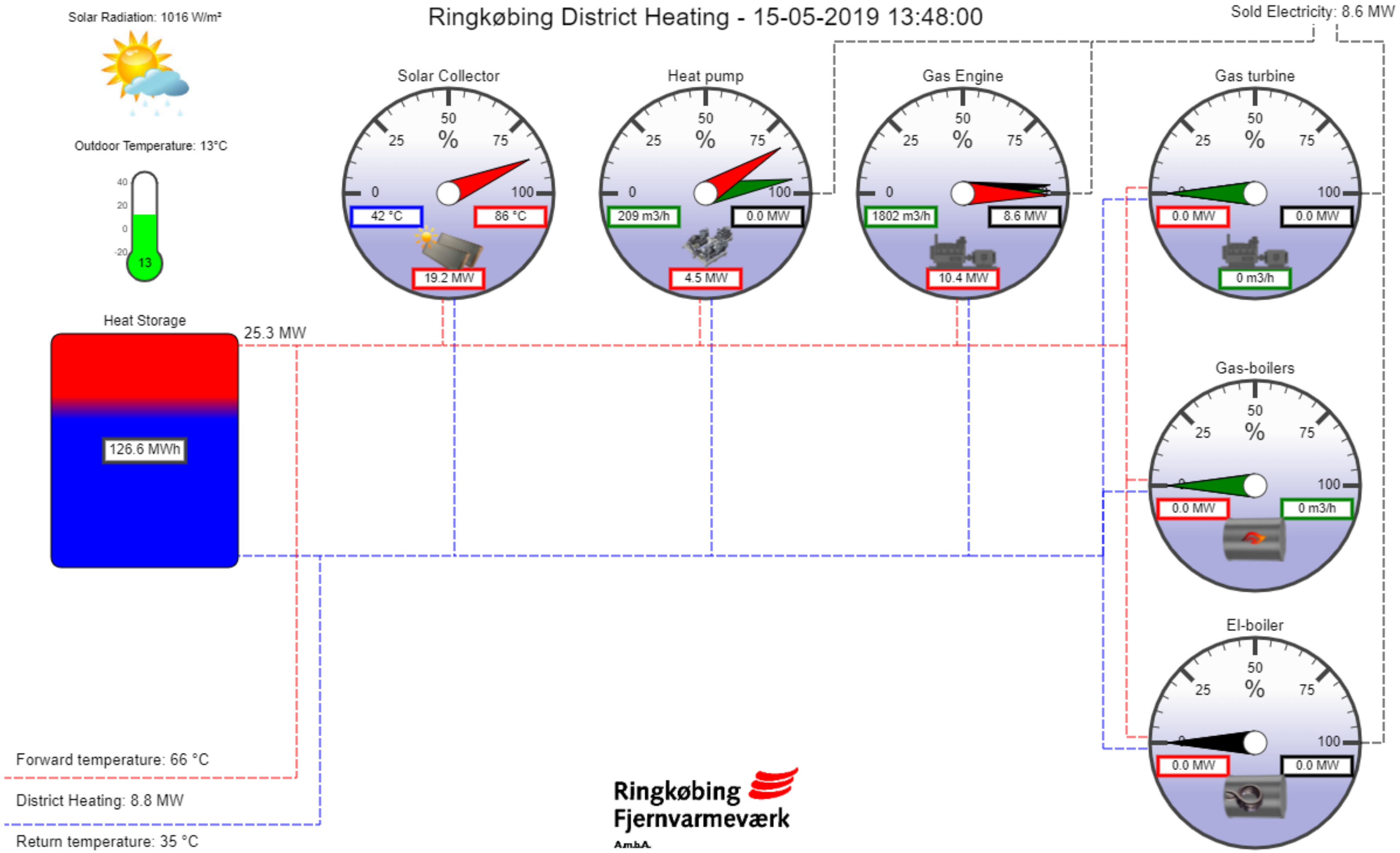
# The Hyde Hendon

- 387 apartments + commercial
- 2 x 39 kW CHP + 2 x 43 kW HP + gas boilers



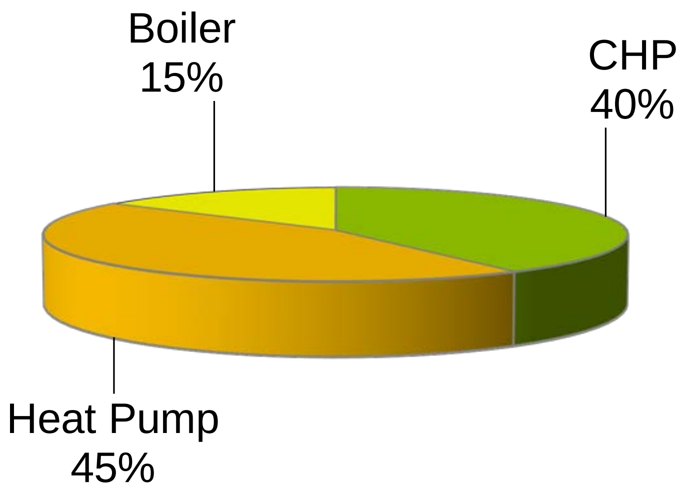

# Ringkøbing District Heating



# Summary - integrating heat pumps

- low return temperature
- large delta T for efficient building
- COP / SCOP
- $CO_2$ reduction
- CAPEX
- OPEX

| HP + CHP + boiler |
| --- |
| 45% + 40% + 15% |

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# Thank you
# for your attention

Beata Blachut - Head of Technical Strategic Business Development

Any feedback or questions: info@sav-systems.com