ENGINEERING
TOMORROW

Heat pumps & good hydronics

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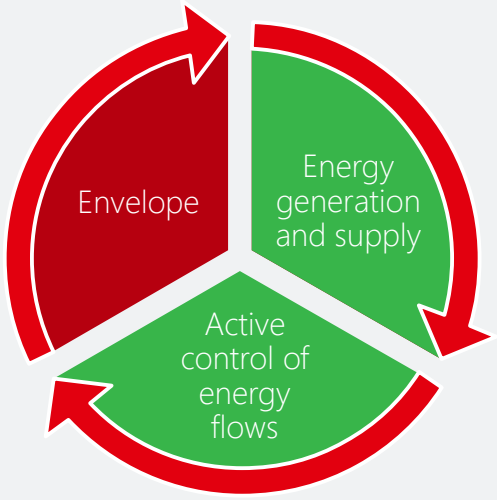
European legislation takes steps forward

Heat pumps are recognized as a key driver towards **renewable** (heating) **energy** in buildings

The 3 pillars of an energy efficient buildings



EPBD
ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE

Increase use of renewable energy

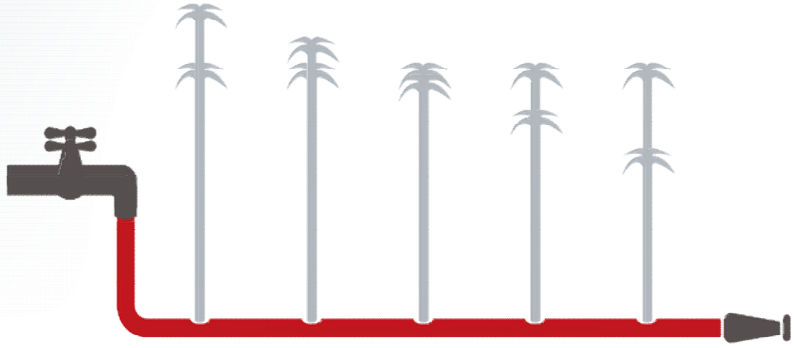
Limit use of primary energy

Legislation

Commercial buildings / Multifamily buildings

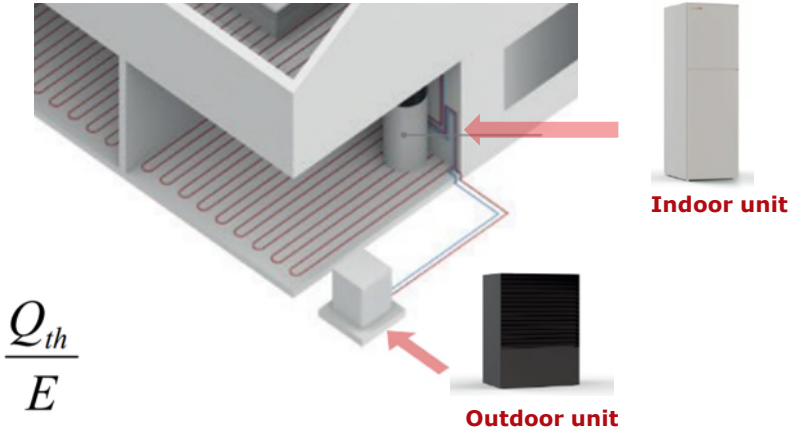
Dynamic Hydronic Balancing & Control

The link between
hydronic balancing and
heat pump performance



How hydronics effects real life system performance

$$COP = \frac{Q_{th}}{E}$$



Commercial heat pump

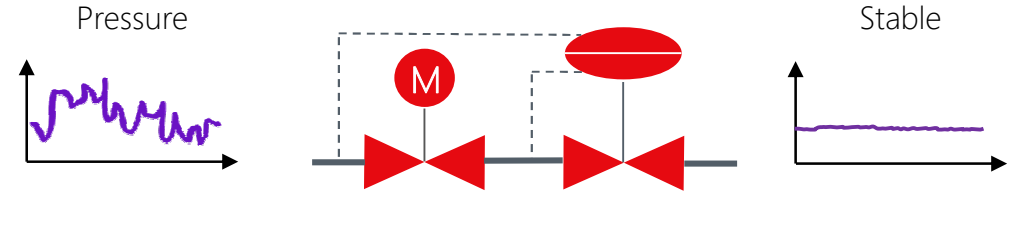
Introduction

Challenge today:

- Heat pump's efficiency in real life often does not match manufacturer 's numbers
- High expected energy consumption and long payback time

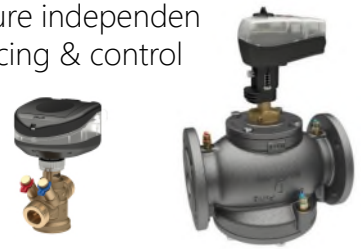
Why good hydronics are relevant for heat pumps and efficiency:

- Heat Pump efficiency improvements
- Longer Heat pump's lifetime



Dynamic balancing

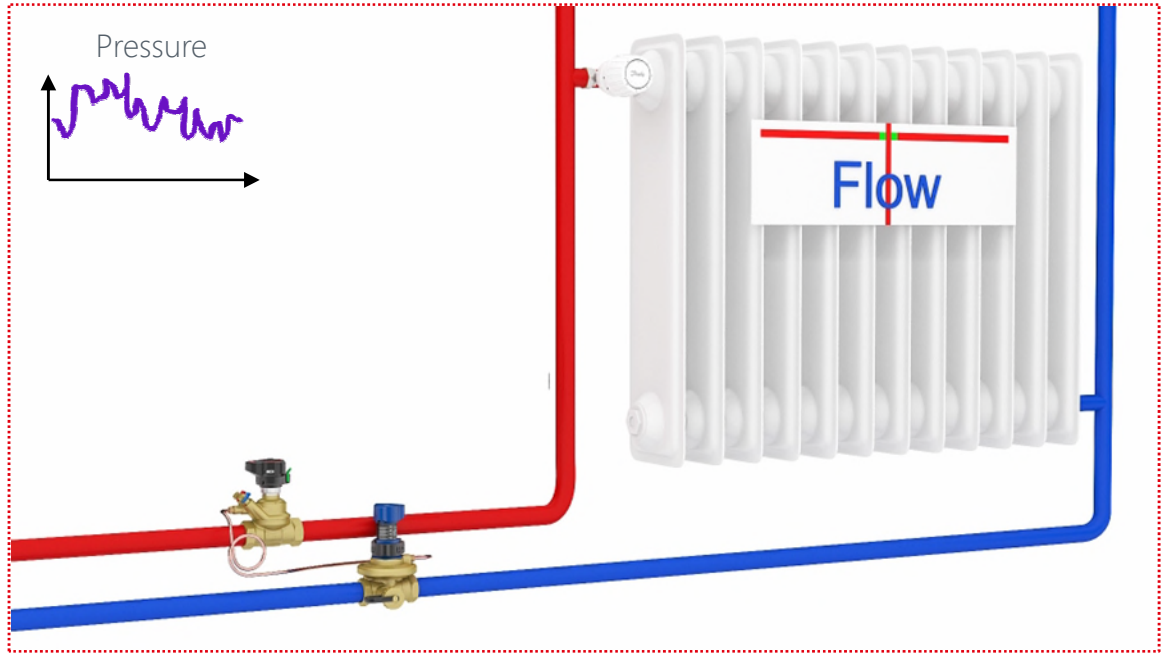
Pressure independen balancing & control

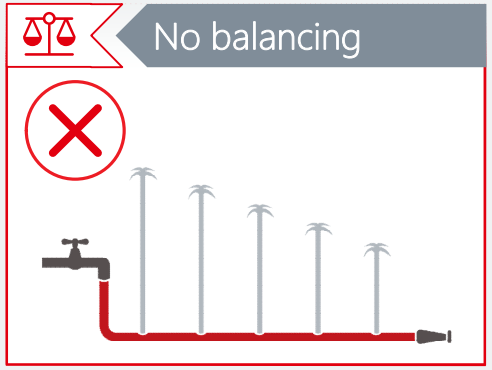


Daily practice of hydronic systems in buildings

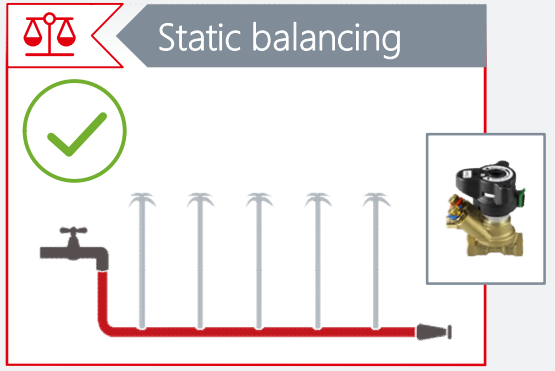
Hydronic balancing

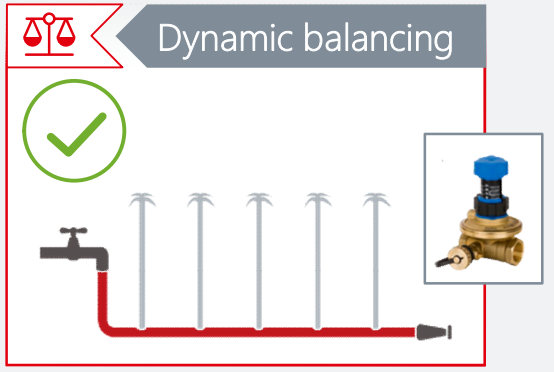
Differential pressure control is needed for correct flows at any condition



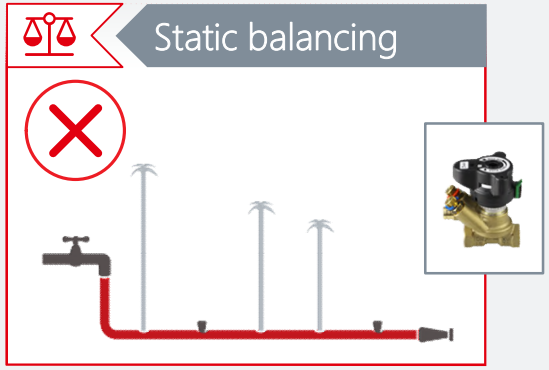


Full load





Partial load



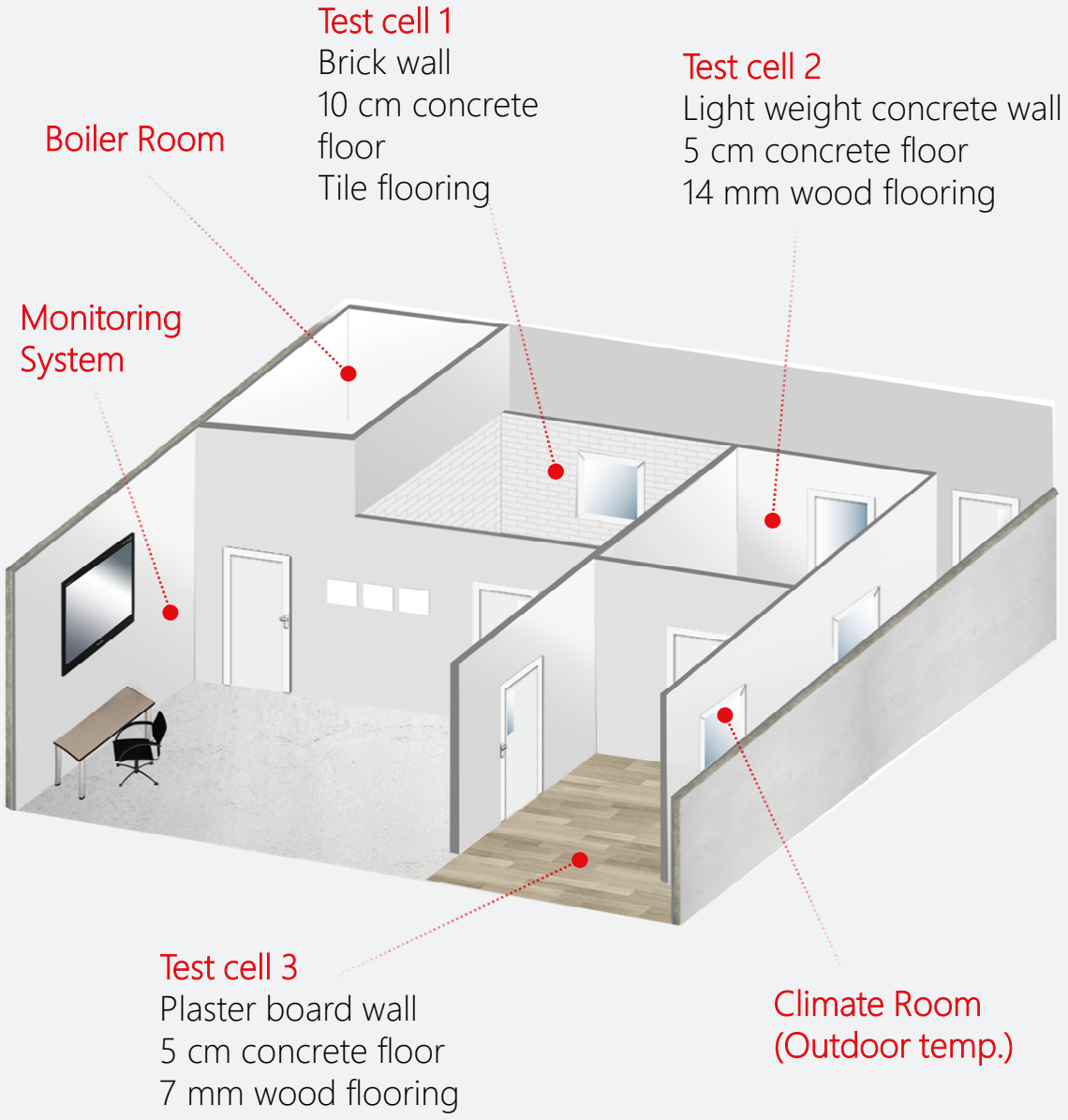
Heat pumps & good hydronics

Case study: dynamic balancing impact

Heat pump & system improvements

Conclusions

Testing real-life conditions



What real life conditions did we test?

Static balancing

Dynamic balancing

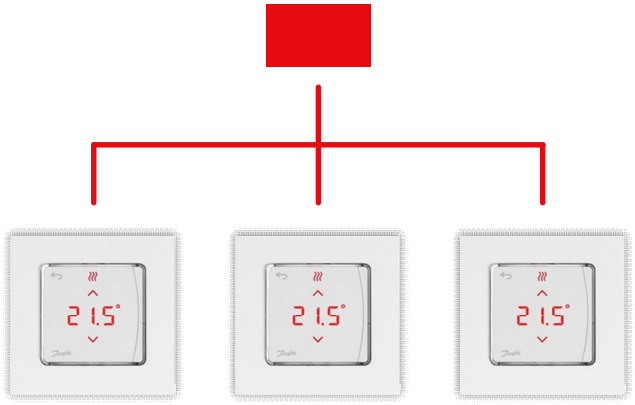
100% room load

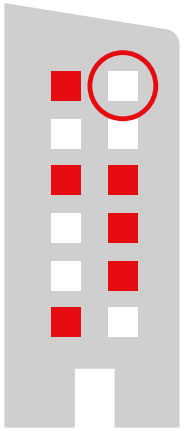
67% room load

33% room load

100% building load
Design conditions

50% building load
Real life

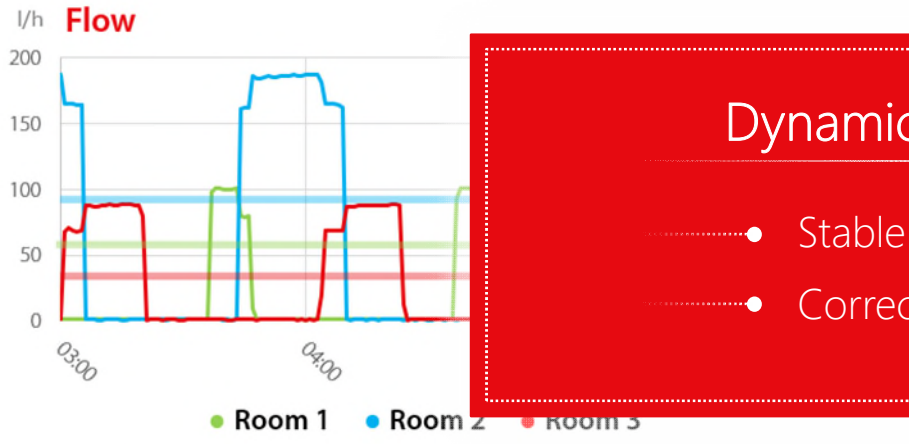




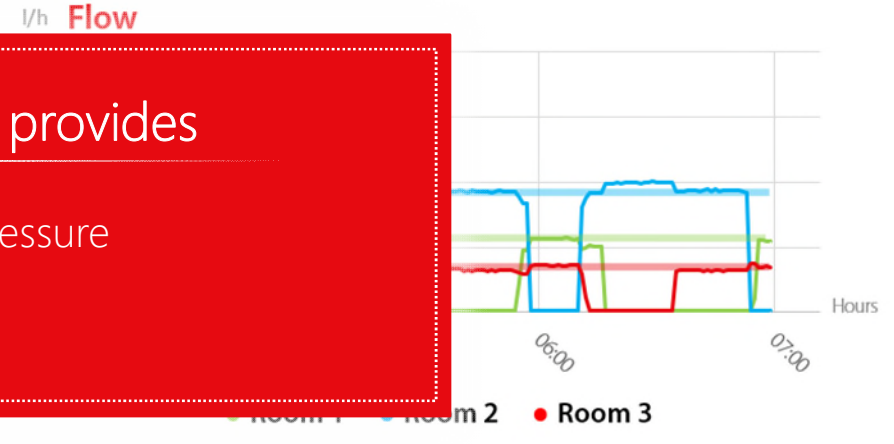
Water differential pressure and flow

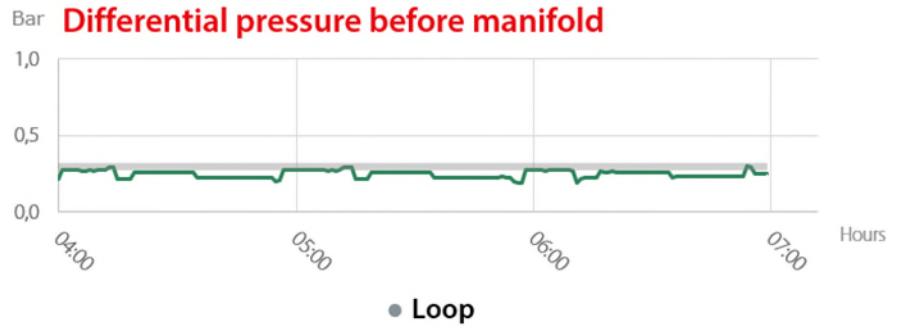
50% building load

Static balancing



Dynamic balancing





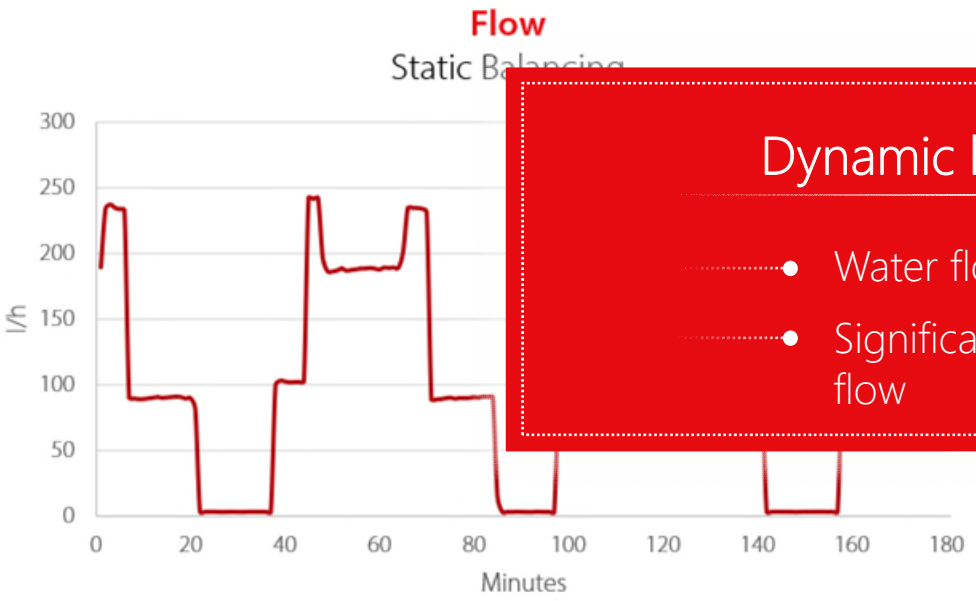
Dynamic balancing provides

- Stable differential pressure
- Correct water flow

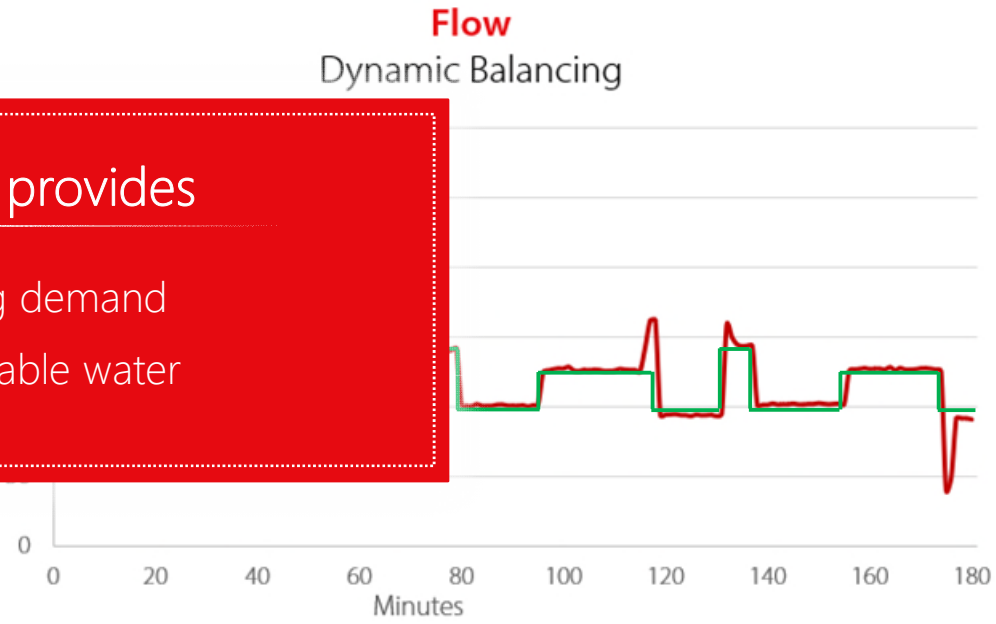
Flow stability

50% building load

Static balancing



Dynamic balancing

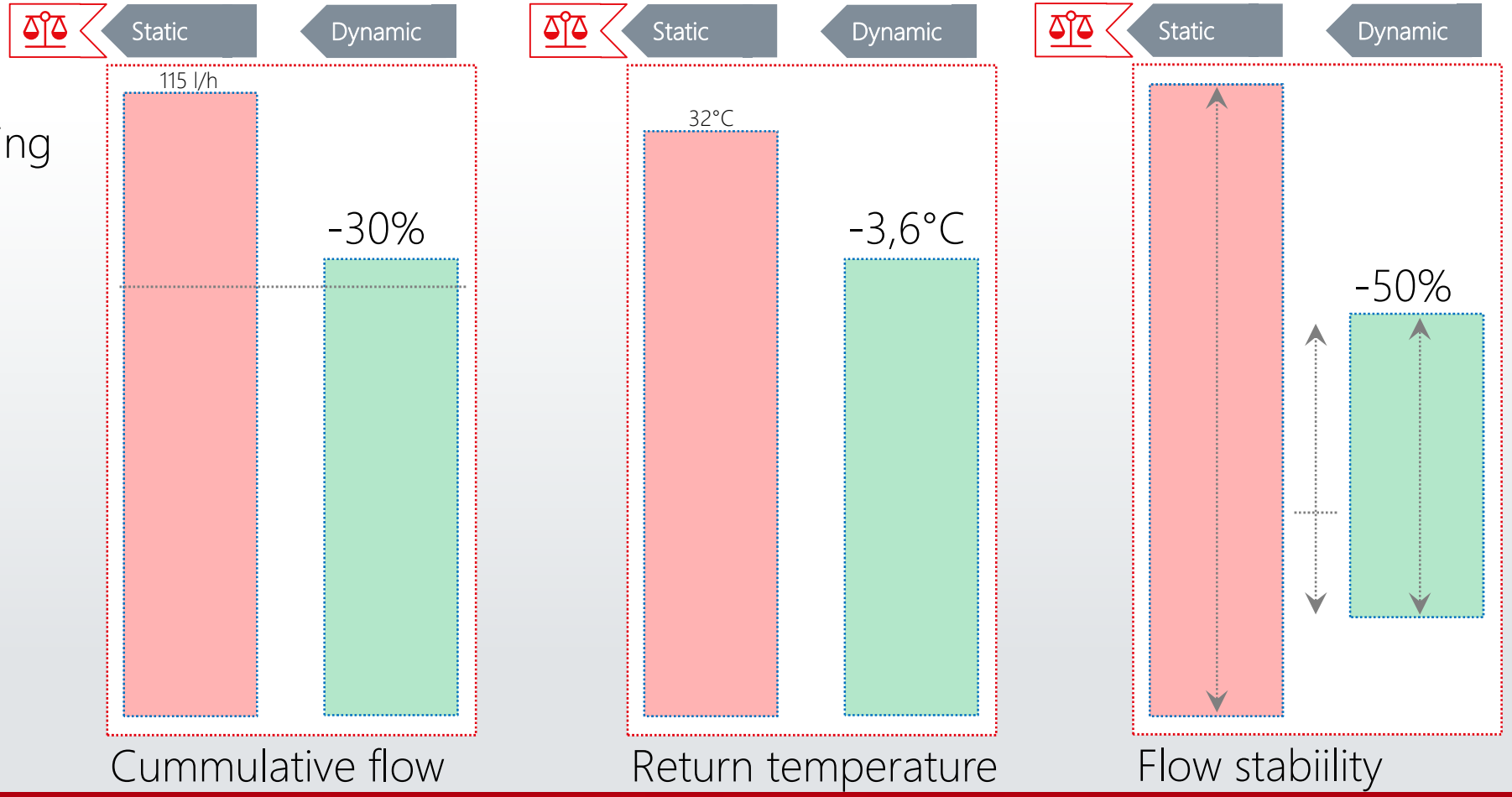


Dynamic balancing provides

- Water flow matching demand
- Significantly more stable water flow

Results sumary

- Dynamic balancing in Multifamily Apartment buildings



Heat pumps & good hydronics

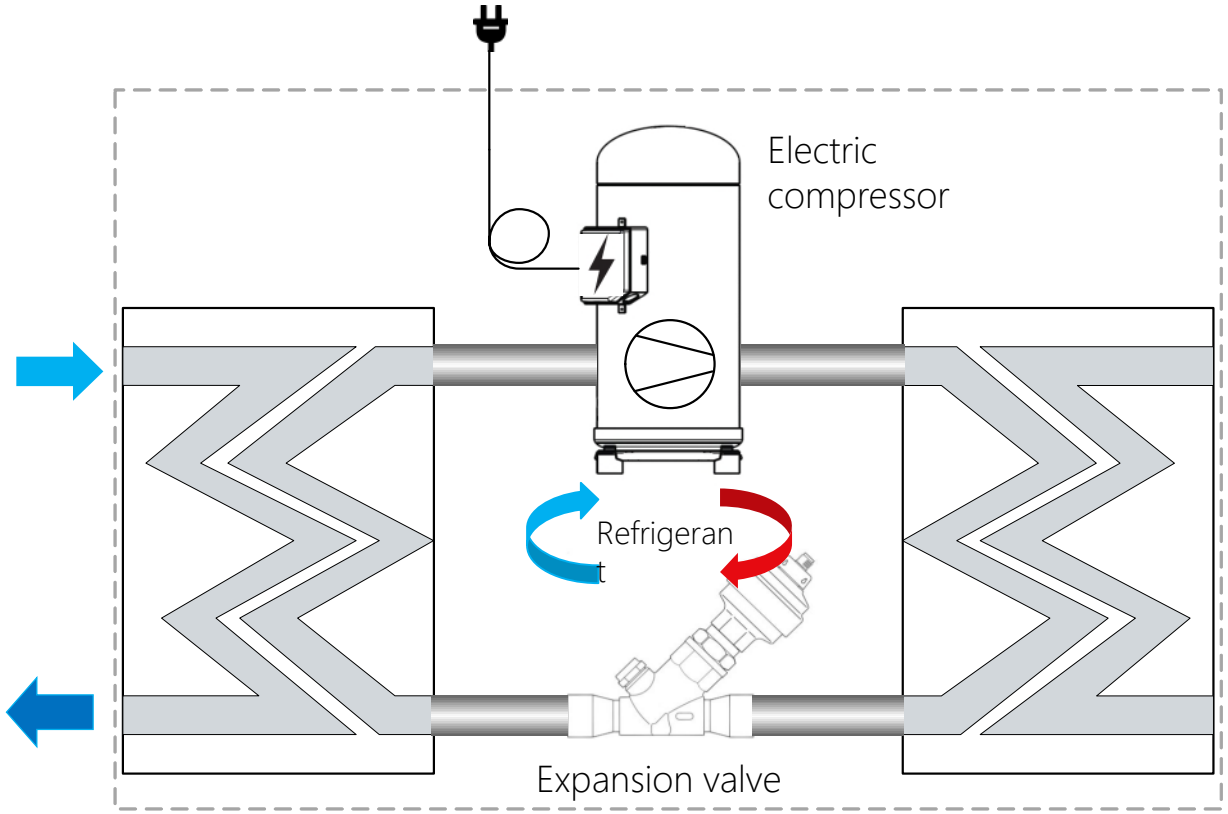
Case study: dynamic balancing impact

Heat pump & system improvements

Conclusions

Knowing the basics

The 5 main components of a Heat Pump



Cold heat exchanger

extracts free of charge
heat from ambient
e.g. ambient air, ground, ...

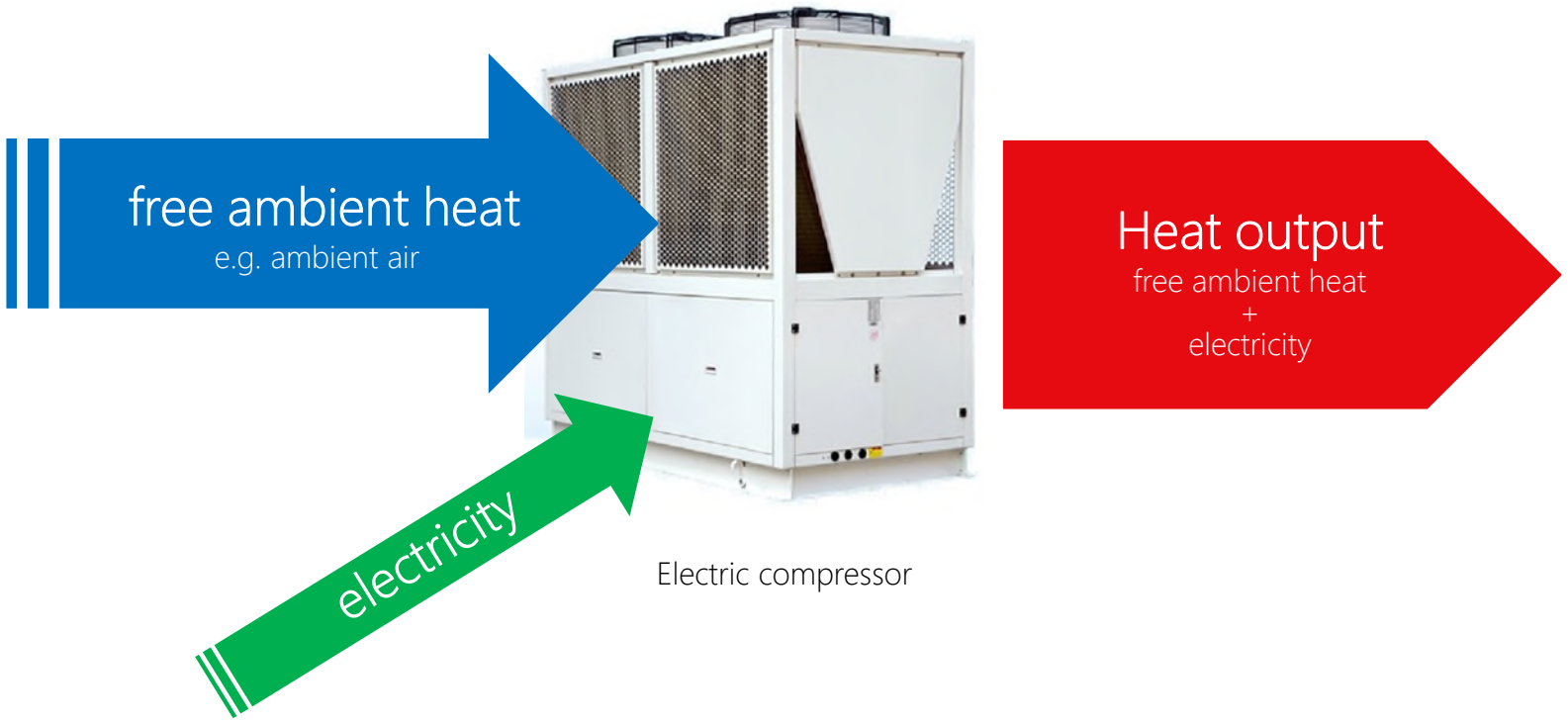
Warm heat exchanger

puts heat into
heating water loop

Knowing the basics

COP Coefficient of Performance
Efficiency at a given moment or operating condition

SEER Seasonal Energy Efficiency Ratio
Efficiency for a certain period – typically one year

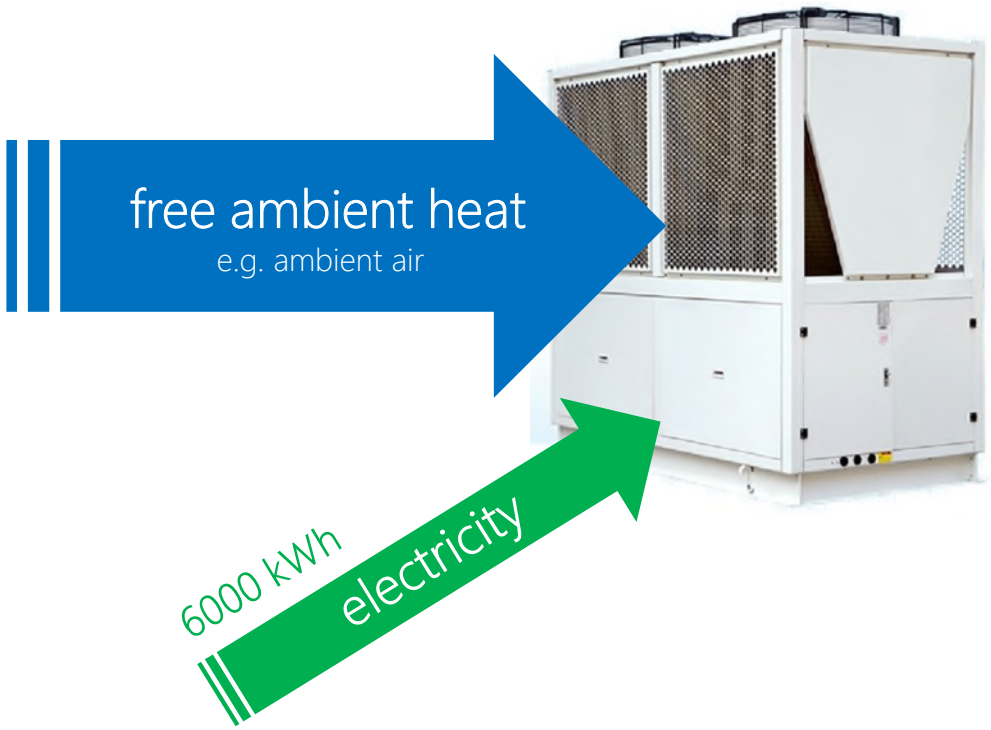


Electric compressor

Knowing the basics

SEER Seasonal Energy Efficiency Ratio

Efficiency for a certain eriod – typically one year



$$\text{SEER} = \frac{\text{heat energy output (kWh)}}{\text{electrical energy (kWh)}}$$

in this example:

$$\text{SEER} = \frac{19200\ \text{kWh}}{6000\ \text{kWh}} = 3{,}2$$

Knowing the basics

COP Coefficient of Performance

Efficiency at a given moment or operating condition

$$COP = \frac{\text{heat power output (kW)}}{\text{electrical power (kW)}}$$

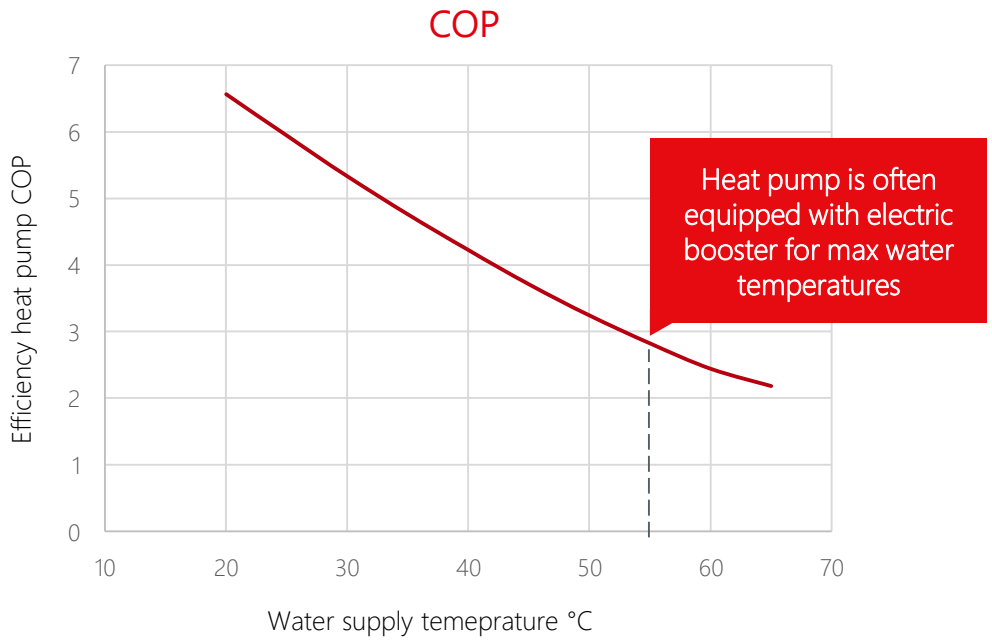
in this example:

$$COP = \frac{38\ kW}{10\ kW} = 3{,}8$$

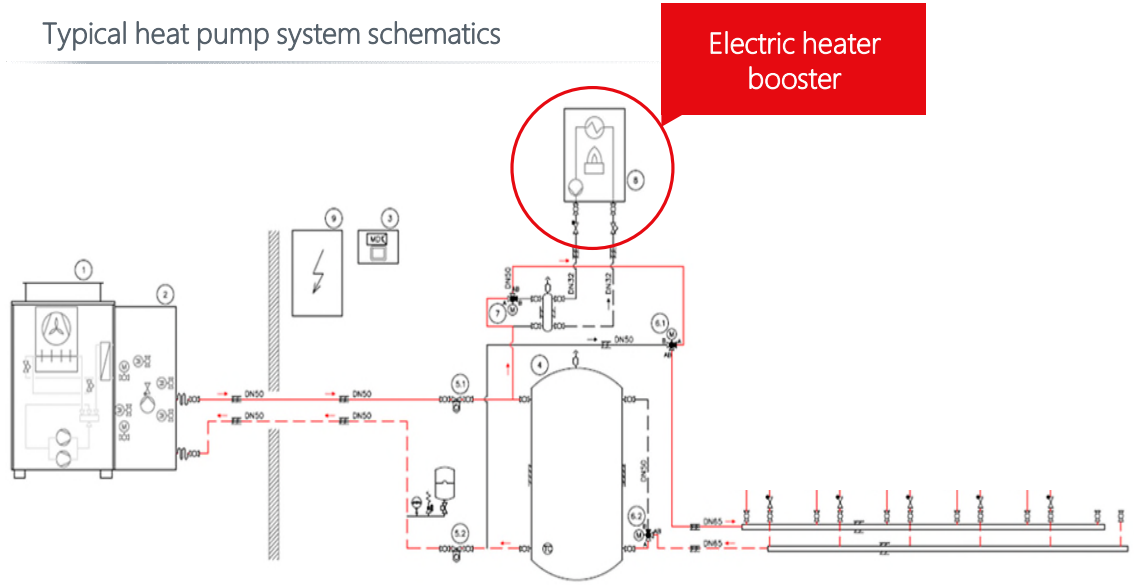
Knowing the basics

COP is strongly influenced by heating water supply temperature

Heat Pump Efficiency for a given ambient temperature



Typical heat pump system schematics

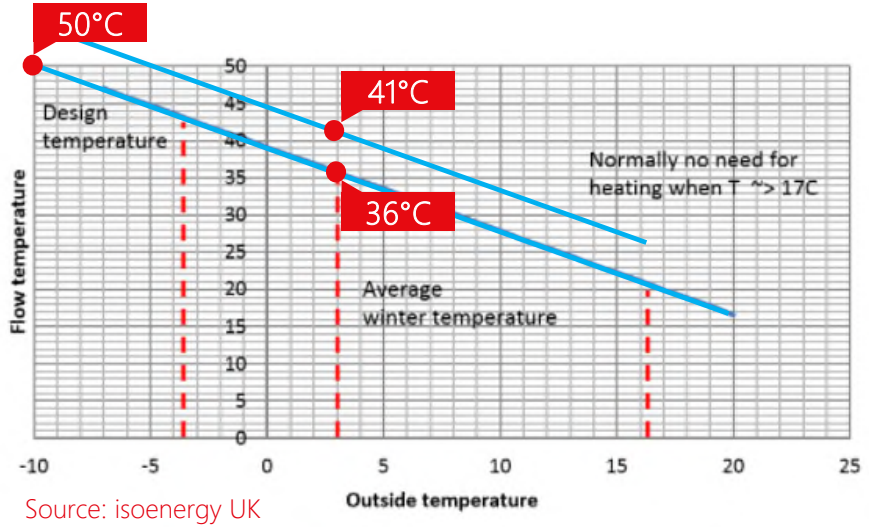


Heat pumps can generate high water supply temperatures but they need low water supply temperatures to be efficient.

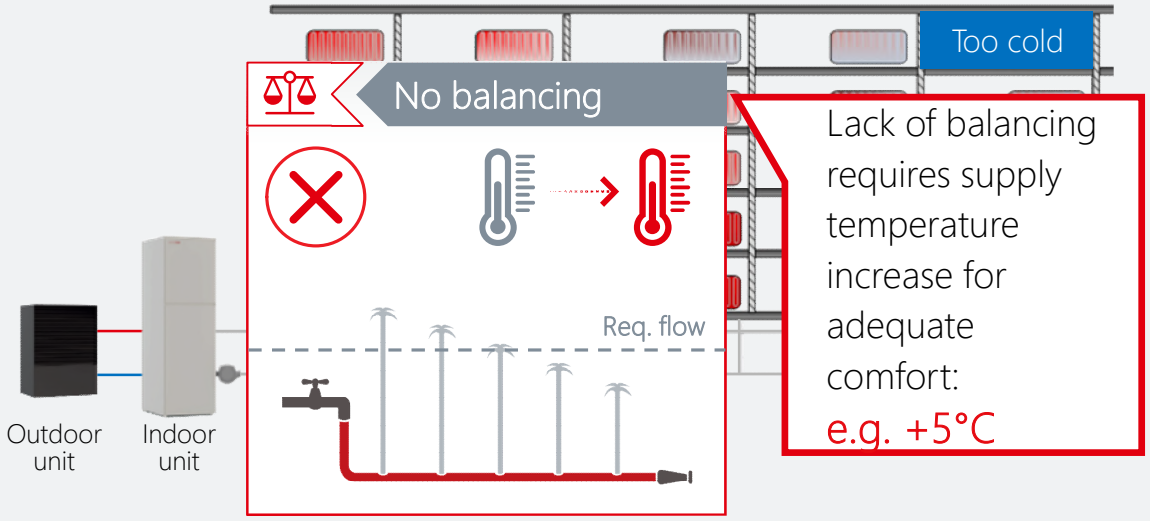
Lower water temperatures
Supply temperature

Design parameters

- Supply water designed for lowest outdoor temperature (e.g. 50°C at -10°C)
- Weather compensation: supply water follows outdoor temperature
- Supply water is lower at average outdoor temperature (e.g. 36°C at +3°C)



Source: isoenergy UK



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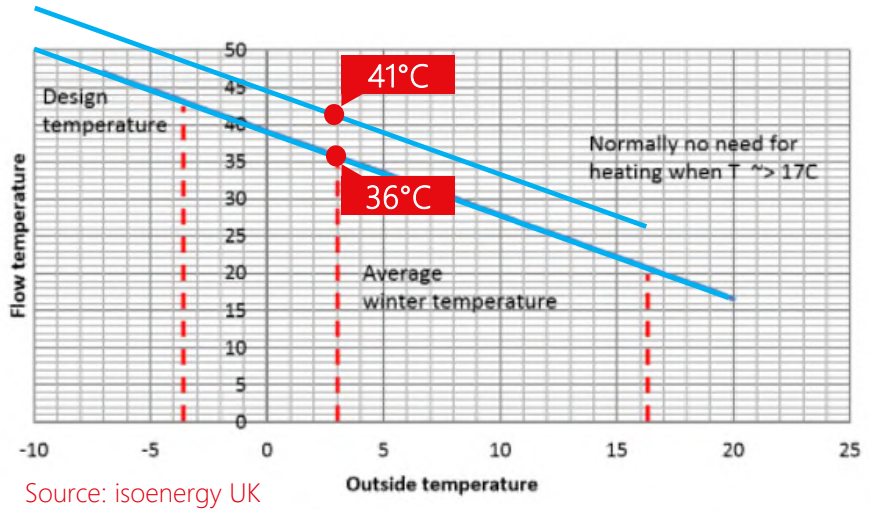

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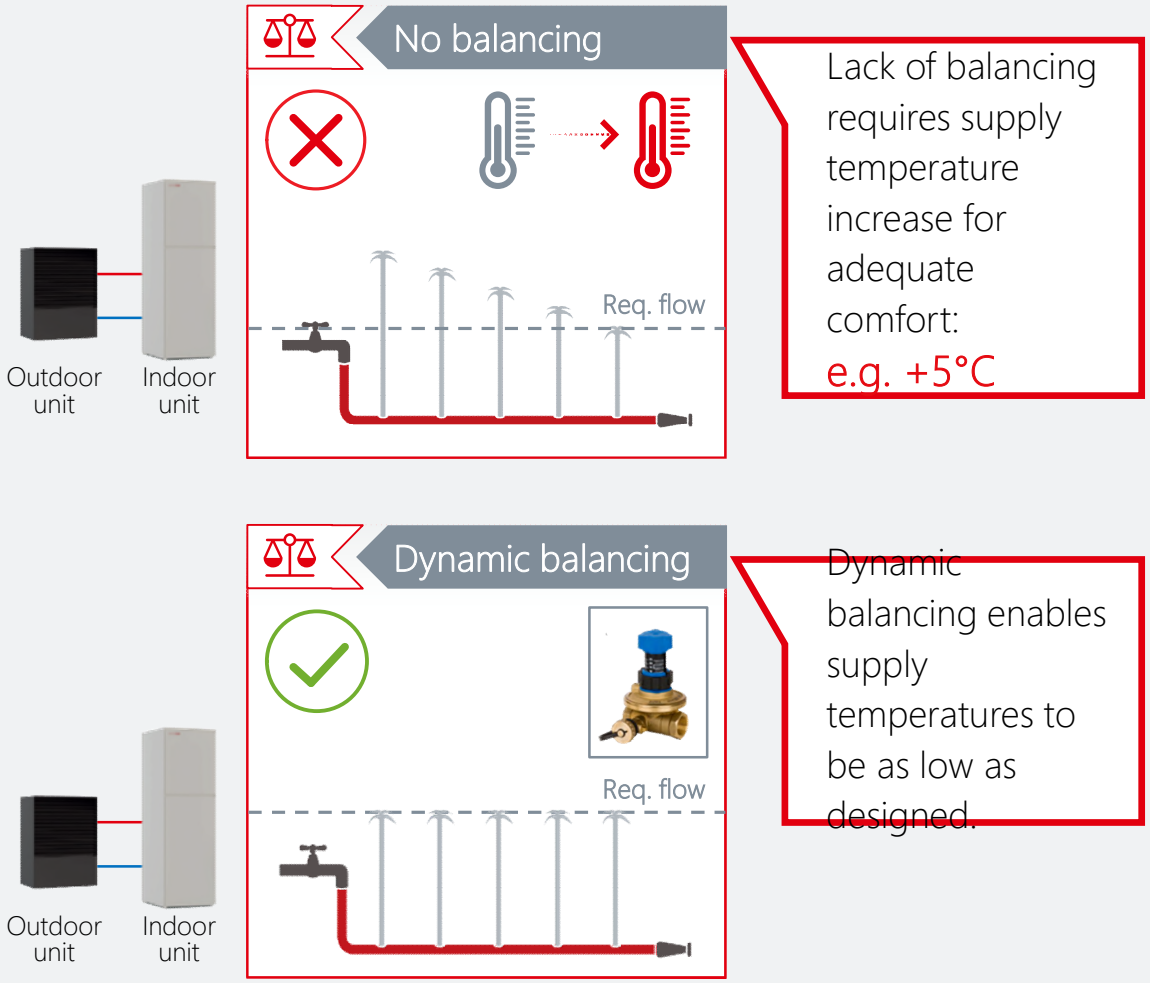


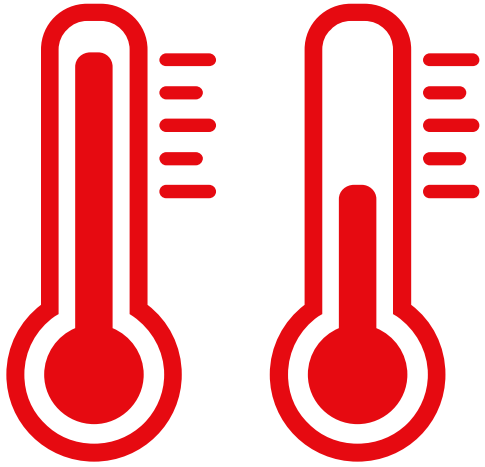
Lower water temperatures: Heat pump efficiency

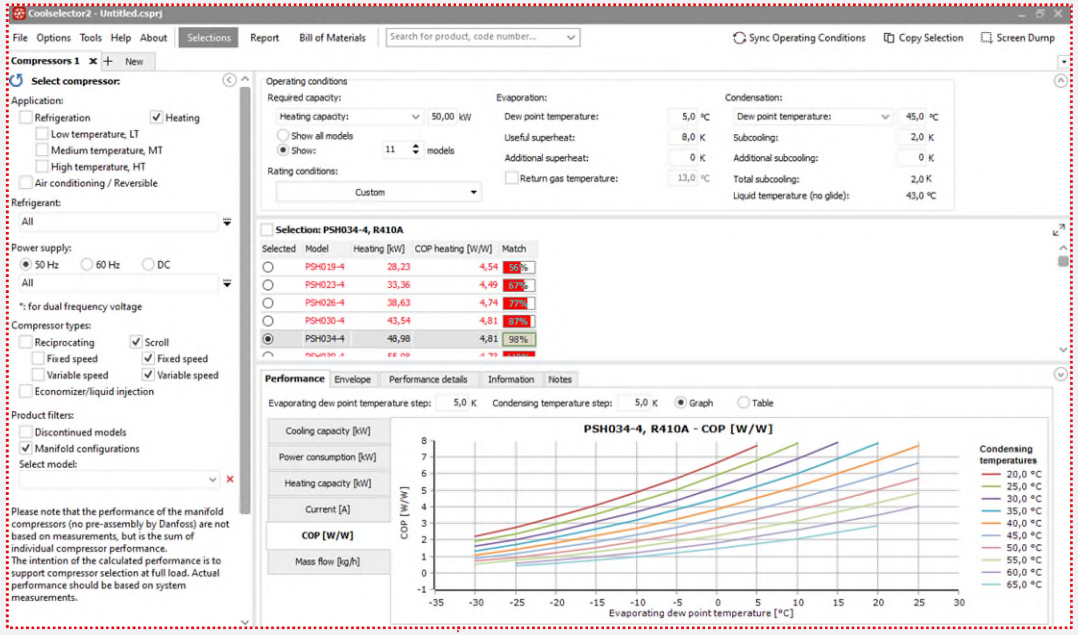
Reduced water supply temperature effect on energy efficiency (COP)

Heat Pump manufacturer's test confirms

10-15%

improved COP for 5 K reduction of heating water supply.





Danfoss CoolSelector software:
2-3% improved COP per 1°K condensing temperature reduction

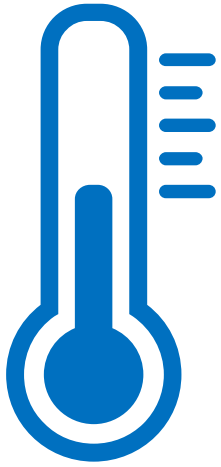
Lower water temperatures: Heat pump efficiency

Reduced water return temperature effect on energy efficiency (COP)

Heat Pump manufacturer's test confirms

approx. 3%

improved COP for 5 K reduction of heating water return.



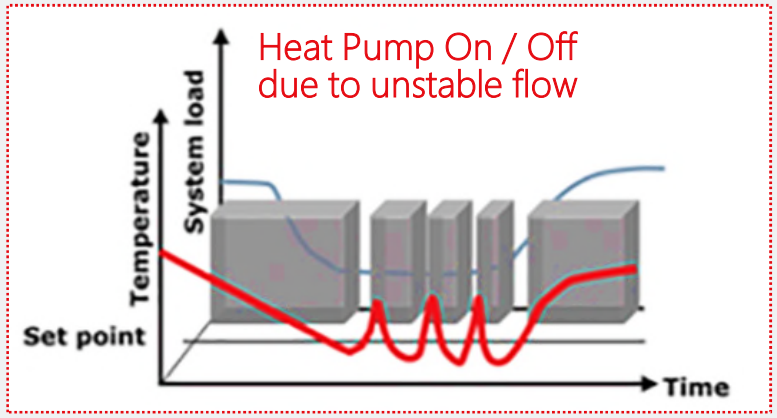
Danfoss Heat pump system simulation : up to 0,6% improved COP per 1°K

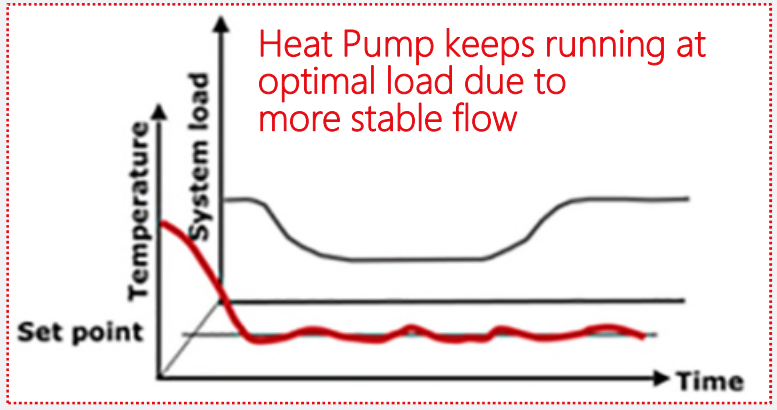
Next step

Real building case study, cooperation with heat pump manufacturer aiming for real life measured figures

Influence of flow stability on heat pump efficiency

- Fluctuations during ON / OFF mode have negative impact on efficiency.
- More stable condition improve heat pump and system efficiency.
- Heat pump efficiency 2% to 5% up





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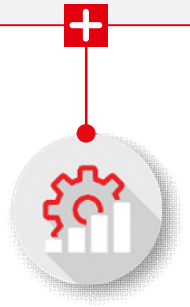
Case study: dynamic balancing impact



Heat pump & system improvements

Conclusions

Hydronic benefits for heat pumps: Conclusions

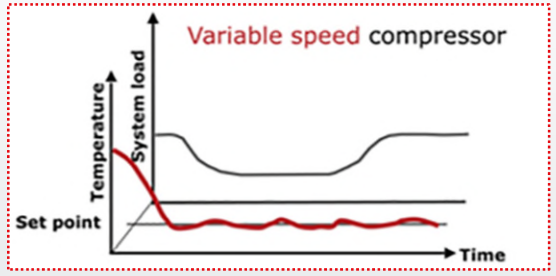
Efficiency:

Supply temperature reduction ..... 2% to 3% per K

Return temperature reduction ..... up to 0.6% per K

10-15% summed up

Stable heat pump operation:



Stable water flow ..... 3% to 5%

Total heat pump efficiency improvement

Saving potential up to 20%

Improved Heat pump efficiency COP

Lifetime:

Longer lifetime due to less on/off switching of compressors