HVAC DISTRIBUTED PUMPING


2022 AWARD WINNER
ES ENGINEERED SYSTEMS
Grundfos
DISTRIBUTED
PUMPING
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WINNER
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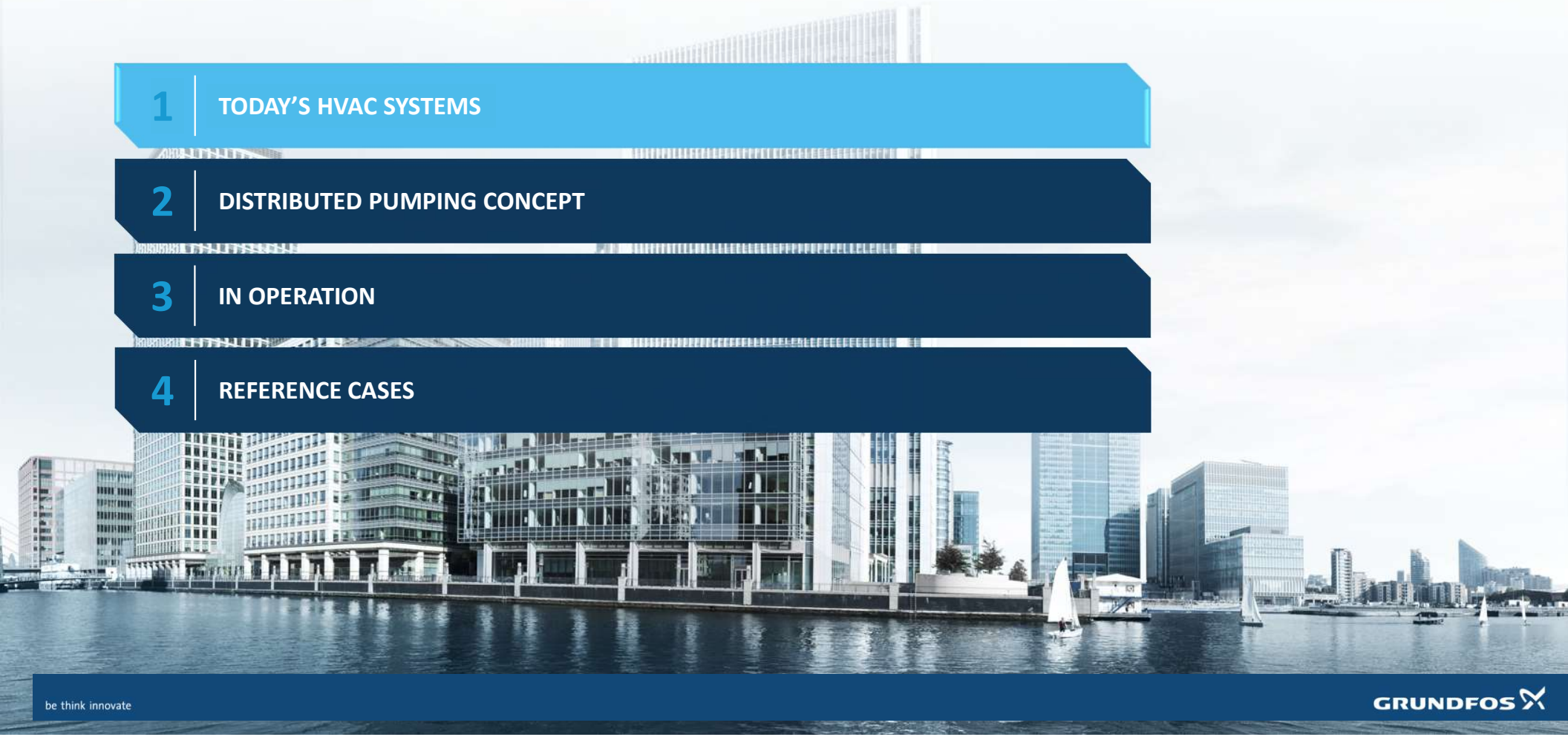
DISTRIBUTED PUMPING - AGENDA

1. TODAY'S HVAC SYSTEMS
2. DISTRIBUTED PUMPING CONCEPT
3. IN OPERATION
4. REFERENCE CASES

DISTRIBUTED PUMPING - AGENDA



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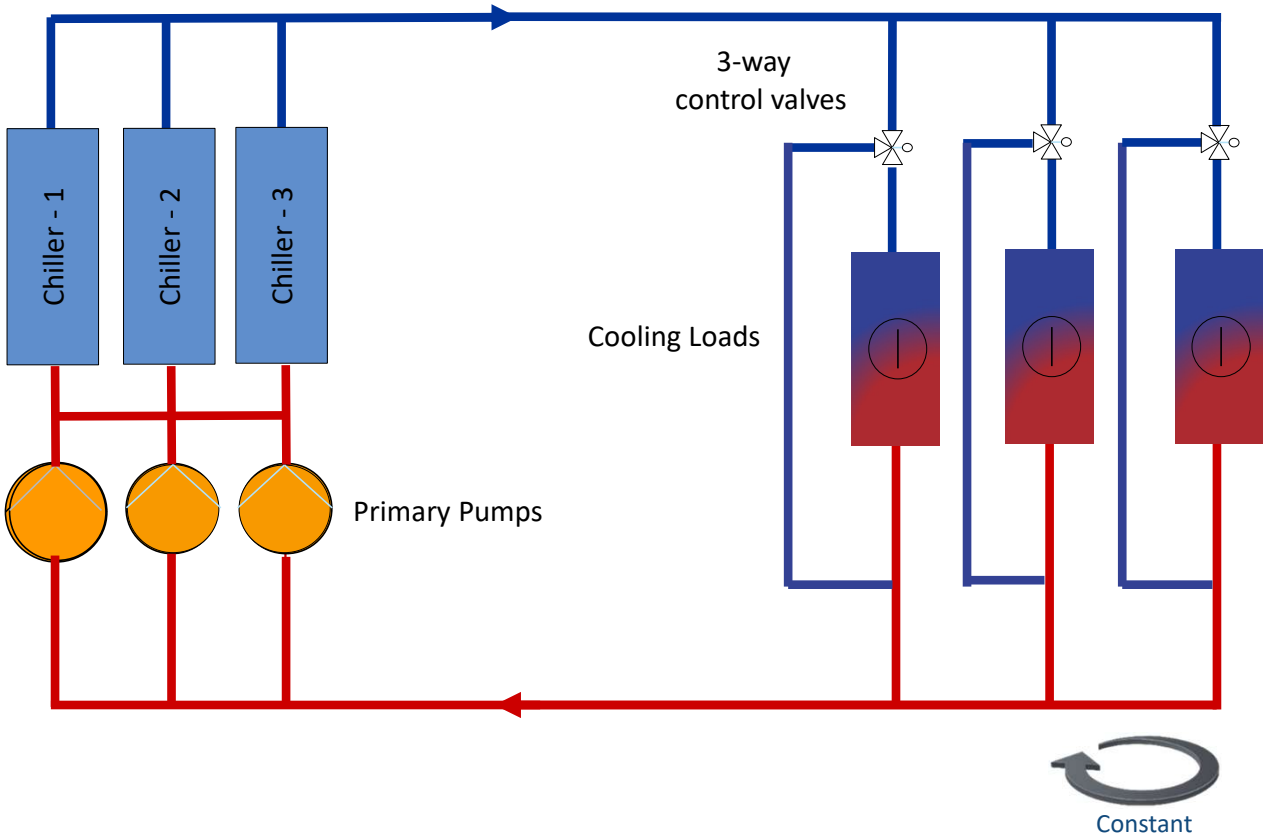
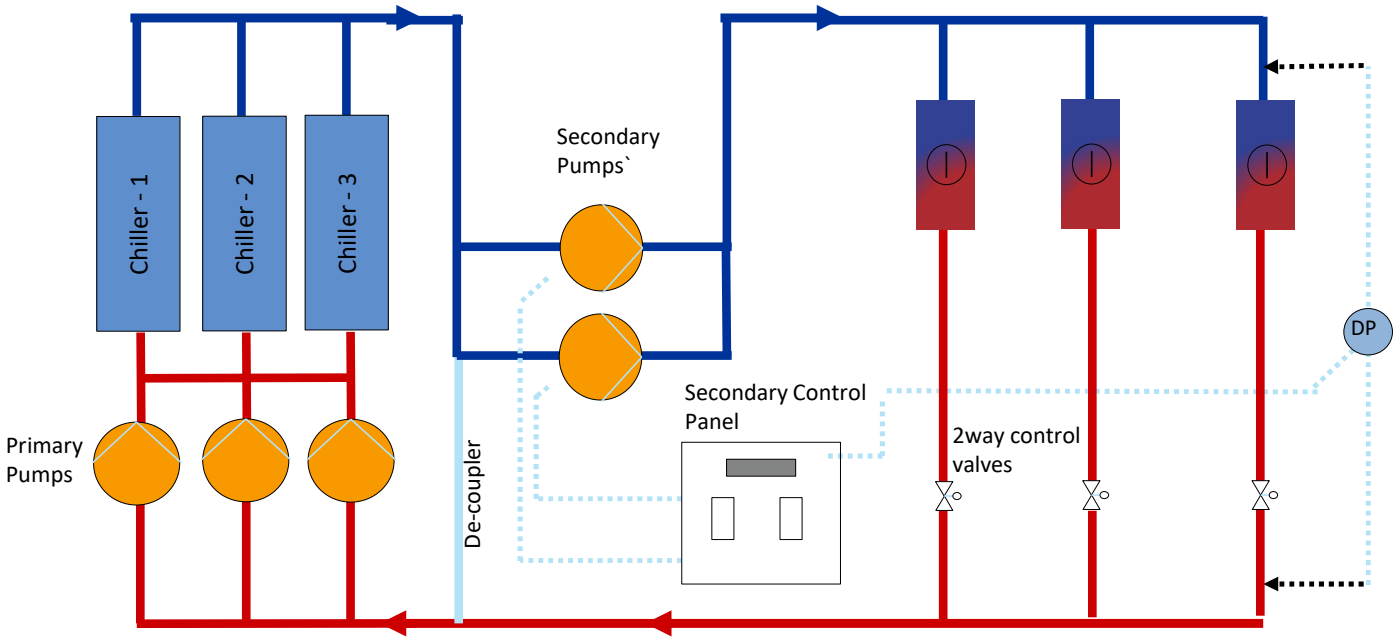
Primary System (constant flow)



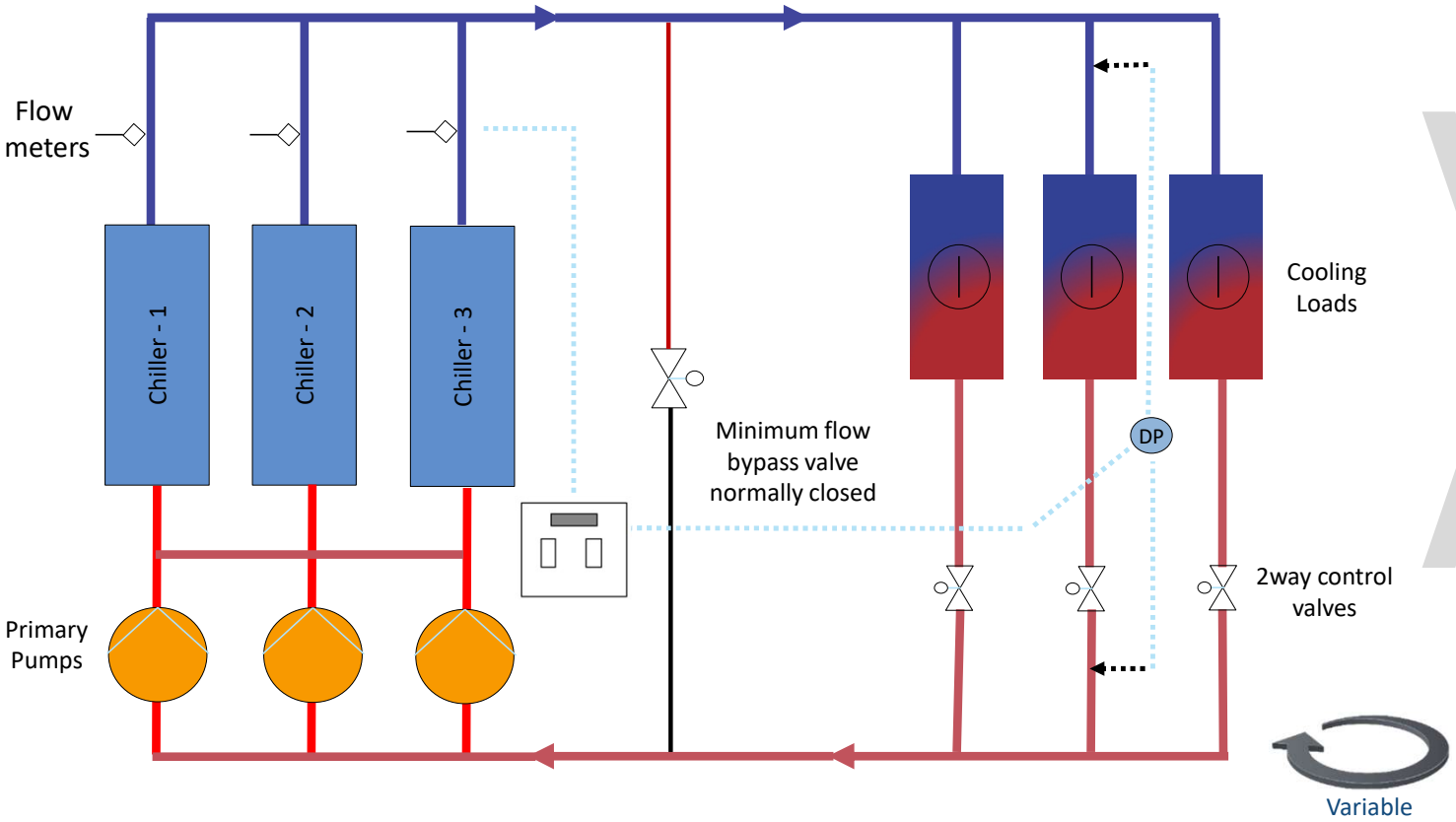
- High pump power consumption
- Loss of cooling performance

Constant Primary / Variable Secondary System



- Constant primary flow
- Variable secondary flow
- More energy efficient

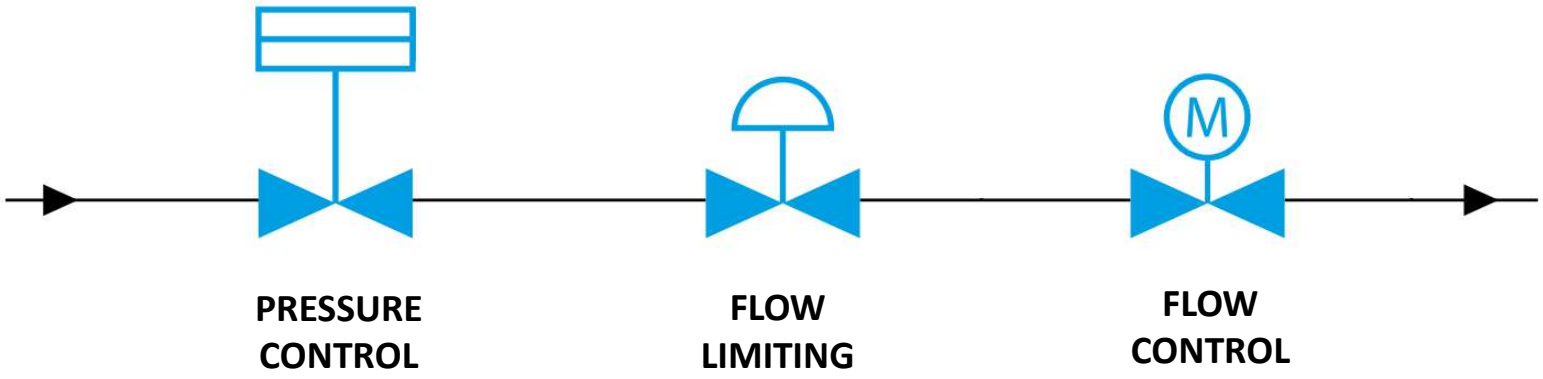
Variable Primary Flow (VPF) System



- Variable primary flow
- More energy efficient

Pressure Independent Control Devices (PIC-D)

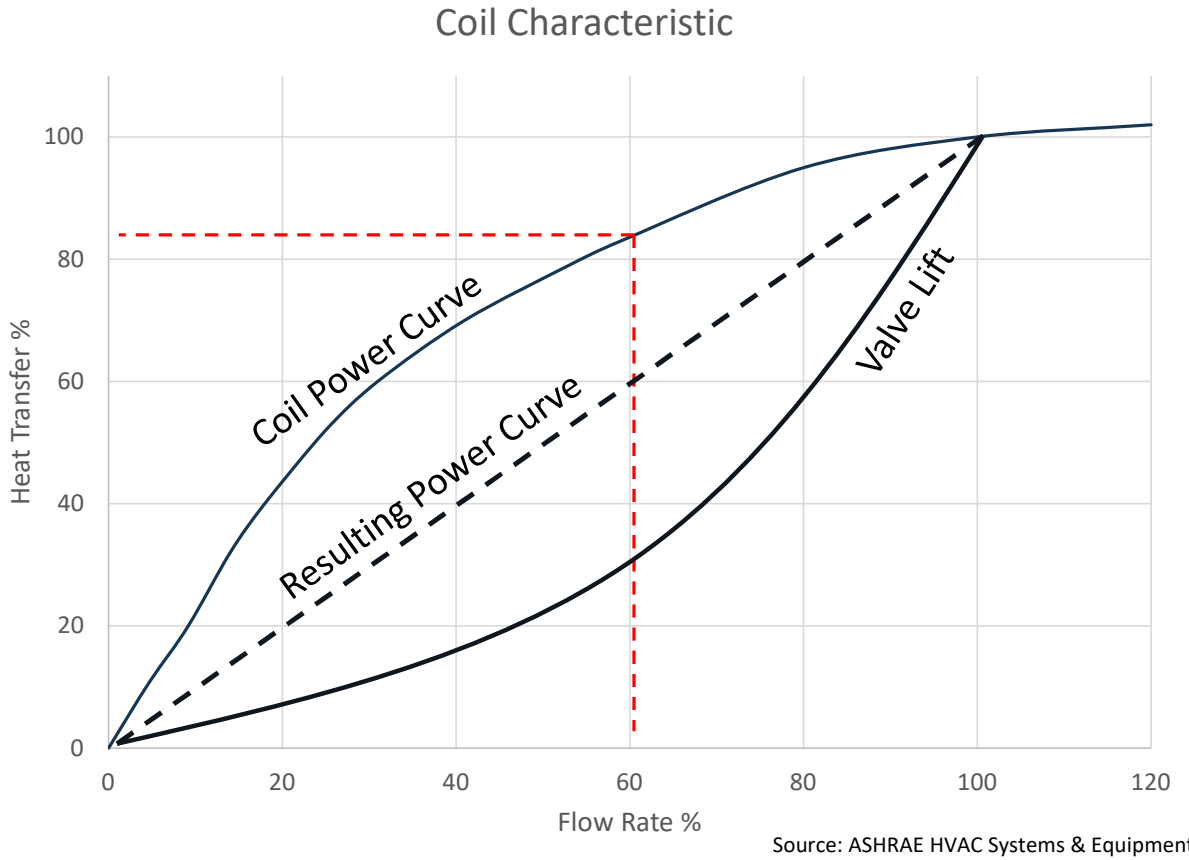
A pressure independent control valve (PIC-V) combines three functions in a hydronic system



Temperature Reference for Pump
Better control of heat transfer

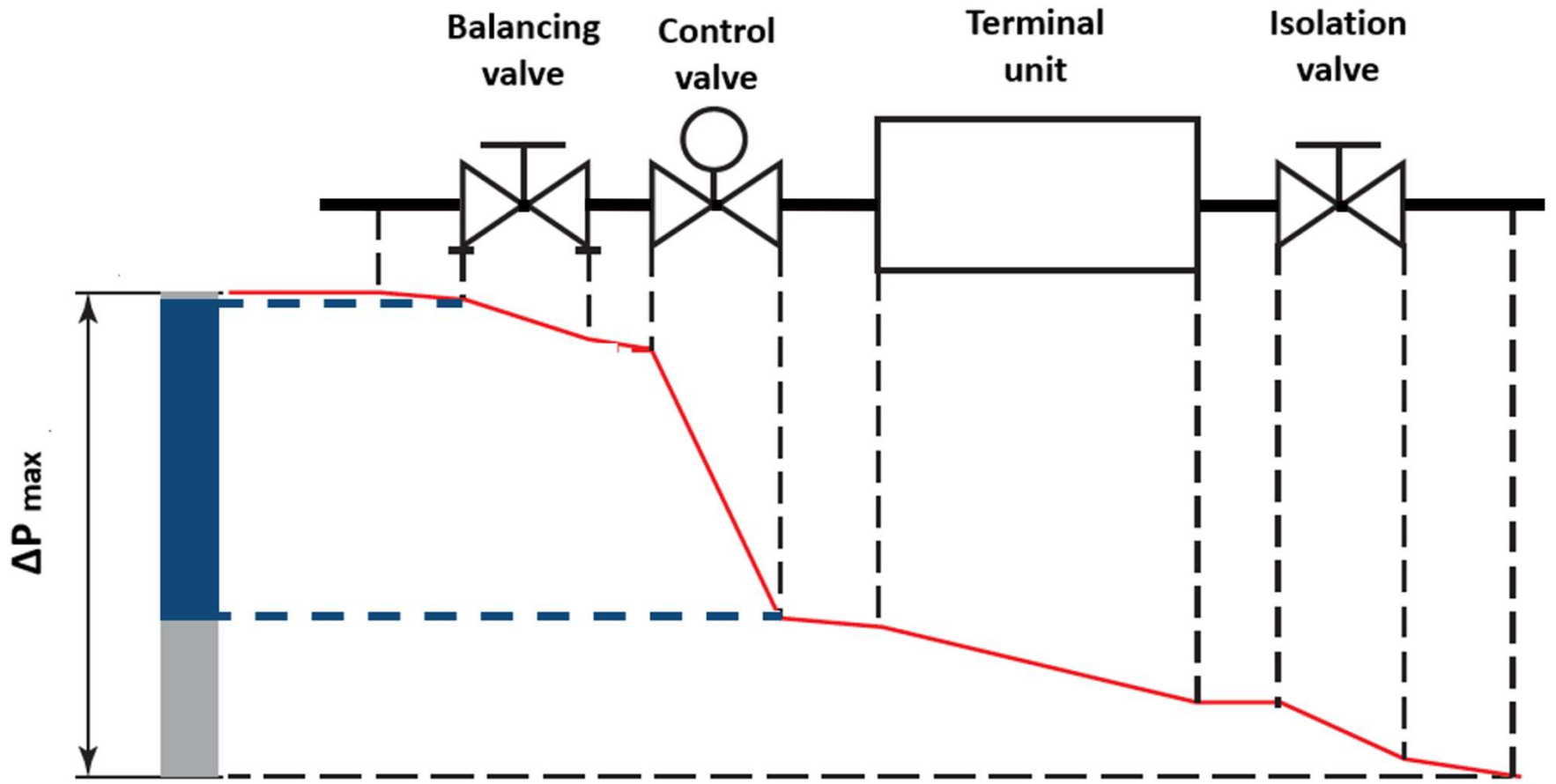
Valve Authority's role
Valve Authority of 1 gives a linear heat transfer if the authority is lower, the controllability is compromised

Distributed Pumping
Pump automatically adjusts the flow to meet the heat load demand



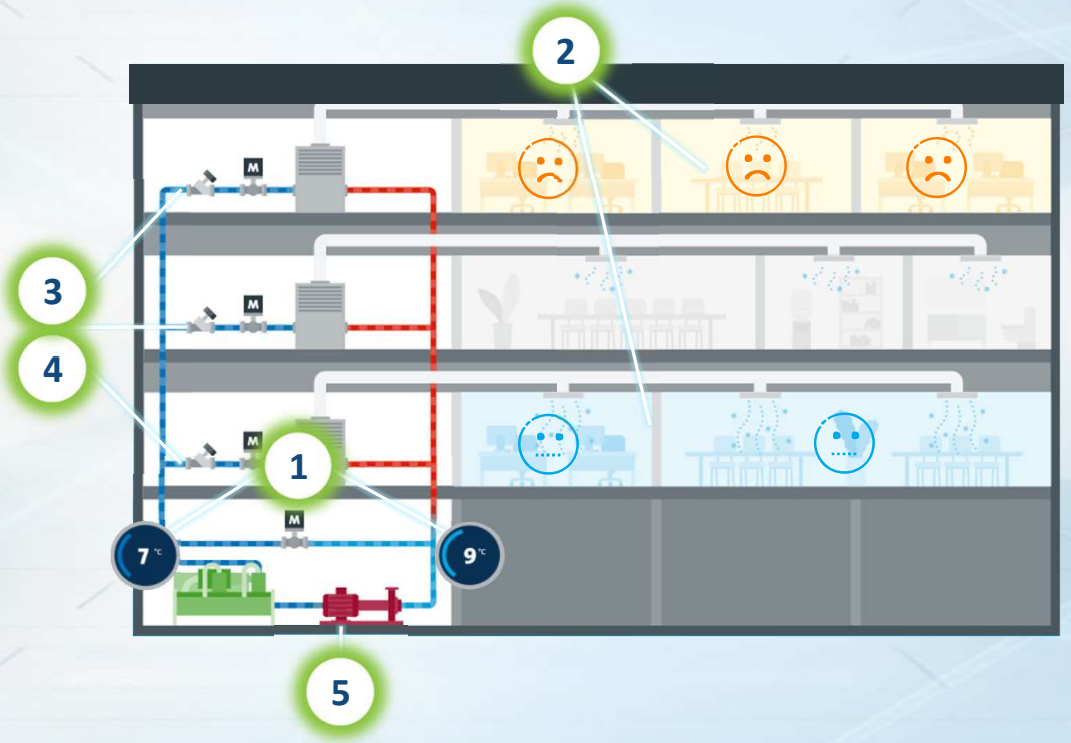
Source: ASHRAE HVAC Systems & Equipment

Terminal Unit Pressure Profile



Common Chilled Water Pain Points

1. Delta T issues
2. Compromised Indoor climate - temperature oscillation
3. Time consuming balancing & commissioning process
4. Complexity in design, installation and commissioning
5. Low efficiency pump management in HVAC systems



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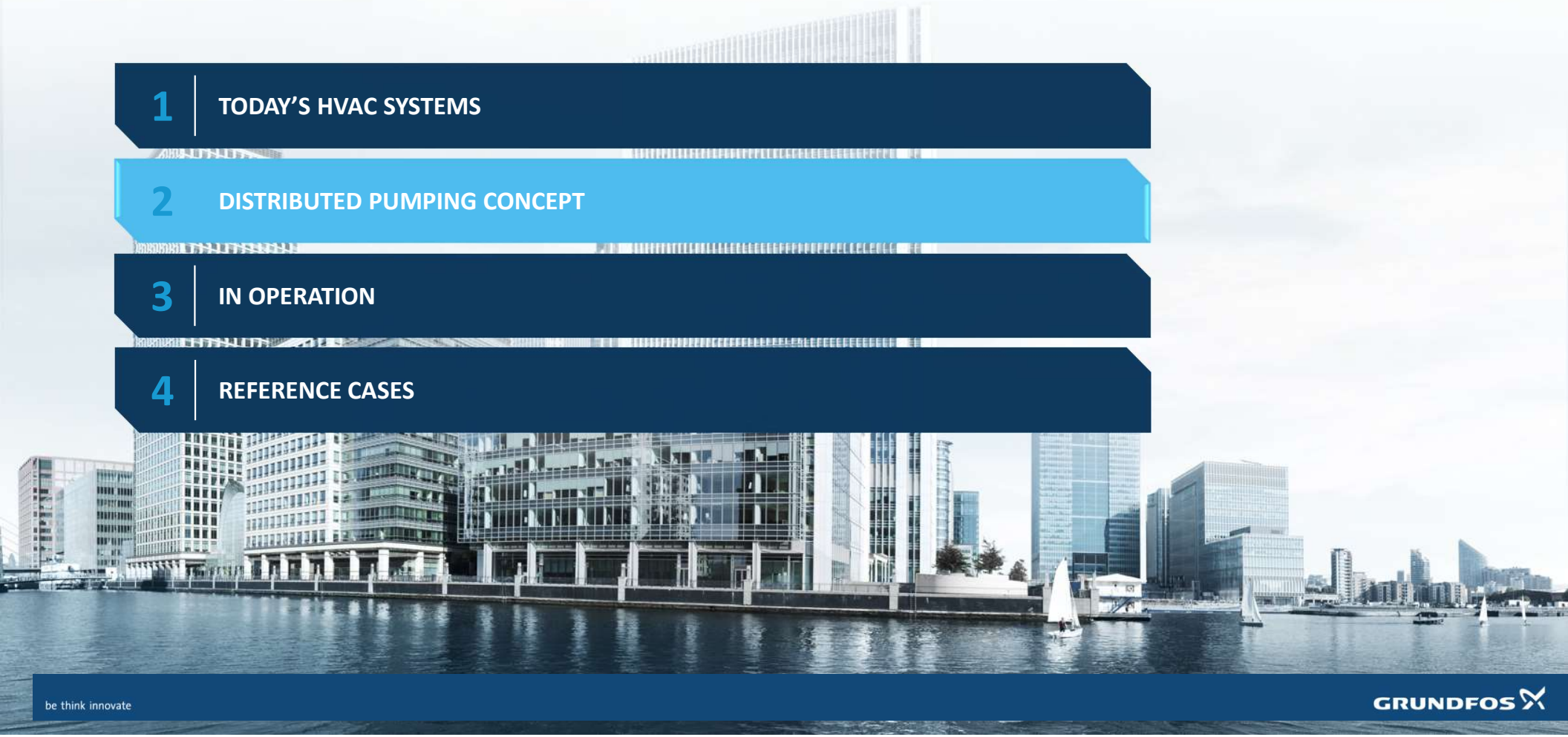

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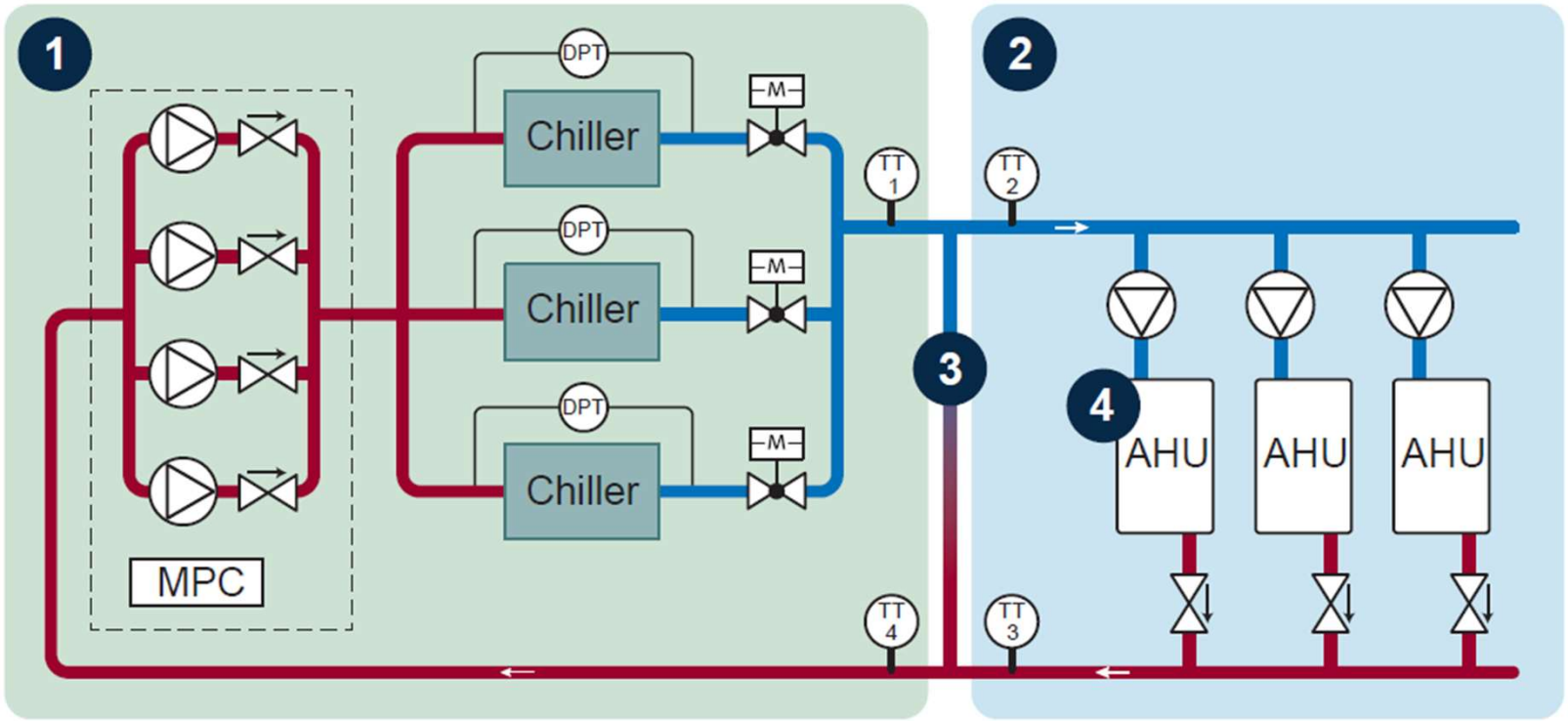
Variable primary/Variable distributed secondary

1. **Primary side**
2. **Secondary side**
3. **Decoupler**
4. **Terminal units**



Of Chilled Wa

Part 1: Chilled Water Distrib

• Connected pump motor hp is reduced. This is due in part because of the customized heads for each pump but also because the control valve is eliminated. Two-way c selected for a wide-open pressure drop 34.4 kPa), about 10 ft (29.9 kPa). This

• Pu This i design. but also maintain

Another disadvantage is the increased exposure to equipment failure. A control valve is extremely reliable— the pump and VFD in this design are more likely to fail. Duplex pumps could be used to improve redundancy, but the cost is prohibitive in most situations. Our philosophy tem. It is usually a little more exp than a primary-only system.

Unfortunately, there are a few disadvantages of this system. First, all coils must have a pump. If a coil were connected to the secondary circuit without a pump, flow through the coil will be backwards from the return to the supply. For a building that has a ssure in the system as there is with conventional secondary pumps. Because of trol of large control valves ently slow due to the size and slow responsiveness of the valve. With the coil pump design, flow can be controlled almost instantaneously with the VFD, so control is precise. There is also no fear of over-pressurizing control valves, which reduces their controllability.

at the same time result in significantly reduced p

• The system is self-balancing. There is no need for balancing valves of any kind nor are there any advantages to self-balancing designs such as reverse-return arrangements.

3. Select condenser water distribution system; 7. Finalize culate pump

Distributed Pumping | The concept

1 The intelligent MAGNA3 assures optimum flow and pressure for each terminal unit while continuously keeping the system in balance, based on input from the sensors (3b).

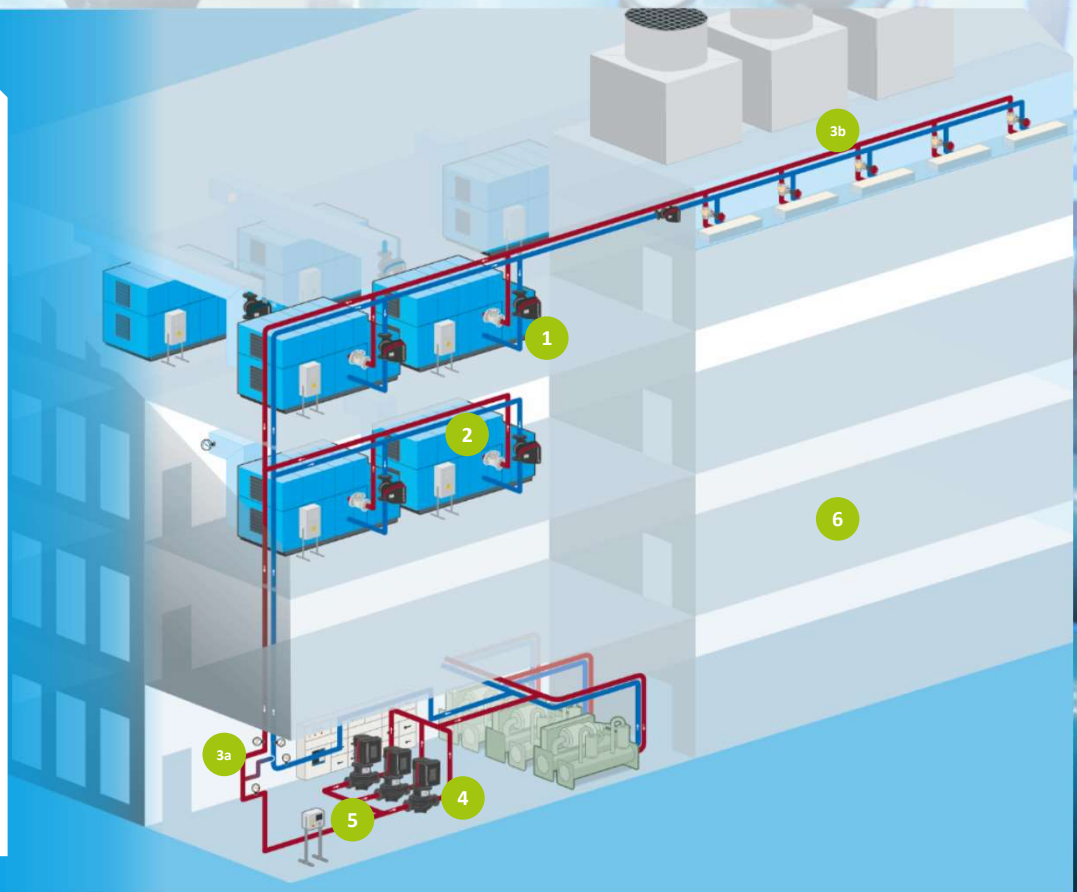
2 The non return valves assure that there is no backflow in the loops where the terminal units are off.

3 A variety of sensing elements (a) can be used for operation of the controller. Air temperature (b) measurement are ensuring that the MAGNA3 adjust in the variable load demand.

4 The primary pumps provide the supply pressure for only the primary side.

5 The controller minimizes the flow in the bypass line, prevents the primary pumps from over pumping and ensure that the chillers' flow is always above their minimum constraint. The controller is connected to the sensors (3a).

6 The complete solution ensures a superior comfort level in the whole building.



DISTRIBUTED PUMPS

MAGNA3 is an intelligent, high-efficiency circulator for HVAC systems

MAGNA3
Distributed Pumps

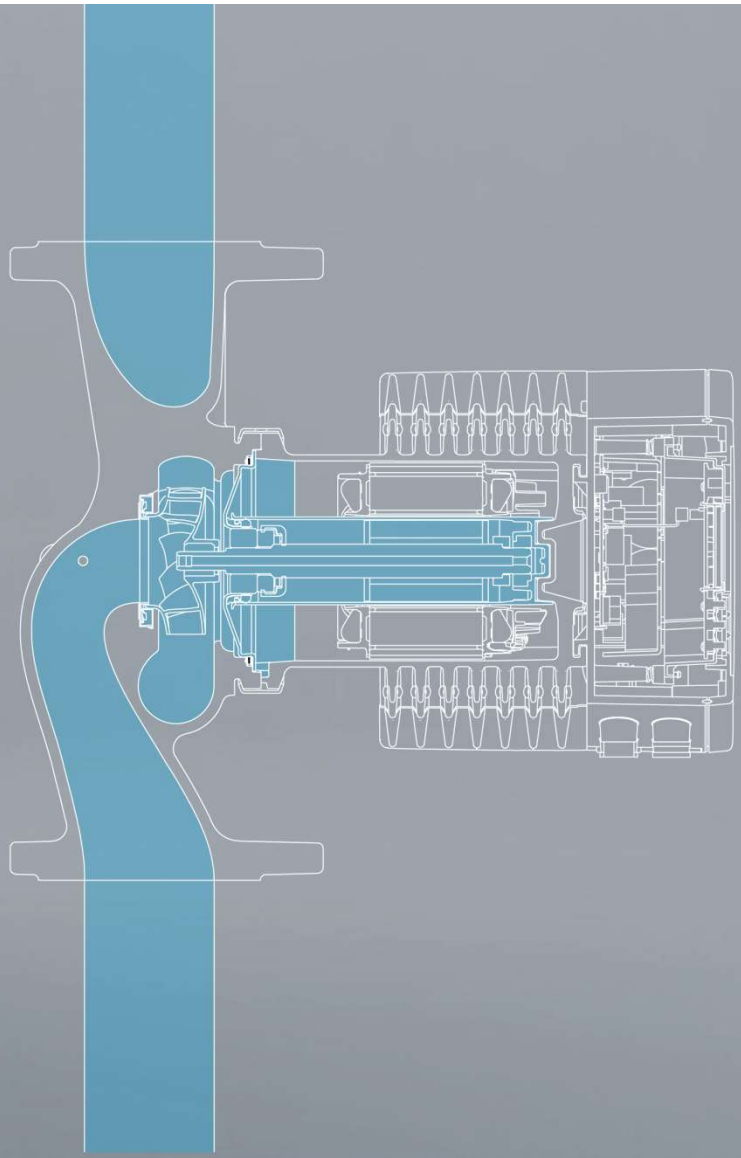
BENEFITS

Intelligent MAGNA3 pumps ensure optimum flow and pressure for each terminal unit while continuously keeping the system in balance, based on input from the sensors.

- ✓ High-efficiency motor and hydraulics
- ✓ FLOWLIMIT and AUTOADAPT reduces energy and installation costs
- ✓ Delta T control mode reduces energy and sensor costs
- ✓ Logging and BMS communications aid system optimisation

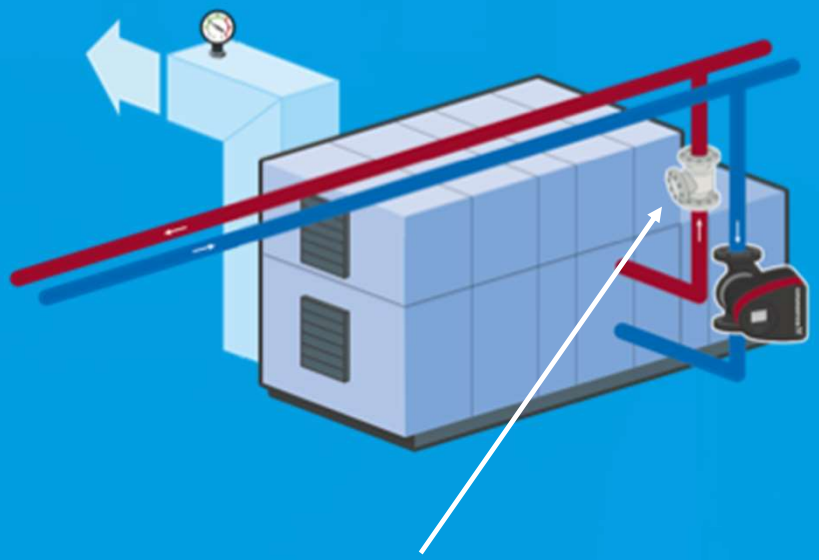
Wet-running design = maintenance-free

Wet-runner pumps with no shaft seals. This non-leakage design makes the pump maintenance-free, allowing you to simply install it without worrying about its future condition.



CHECK VALVE

The non-return valve prevents backflow



Check valve
A check valve allows a medium to flow in only one direction.

BENEFITS

Each dedicated distributed pump is installed with a check valve at each air handling unit (AHU).

The check valve prevents backflow in case the AHU must be shut down.

PRIMARY PUMPS

Primary pump system with chiller protection and bypass controls

Primary pumps + controls

The primary pumps provide precise flow and pressure only for the variable primary chiller loop

- ✓ High-efficiency motors and hydraulics
- ✓ Onboard controls provide chiller protection and Delta T control for the 4-temperature bypass simplifying instal and reducing energy
- ✓ Pre-programmed controls and start-up guides speed installation and commissioning
- ✓ Logging and BMS communication aid system optimisation

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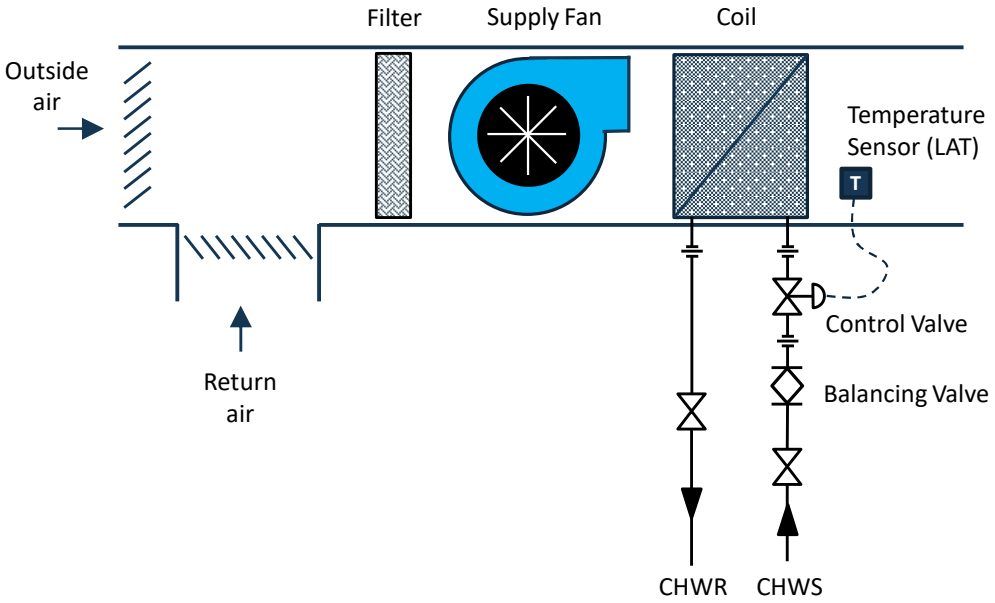
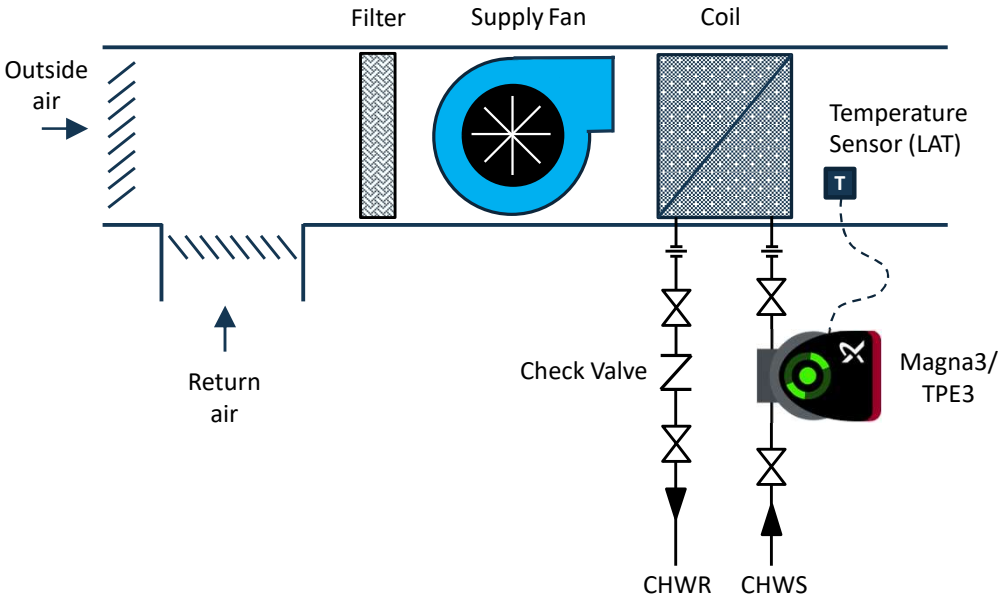
Typical AHU Coil Piping with Control Valve



AHU Coil Piping with Magna3/TPE3

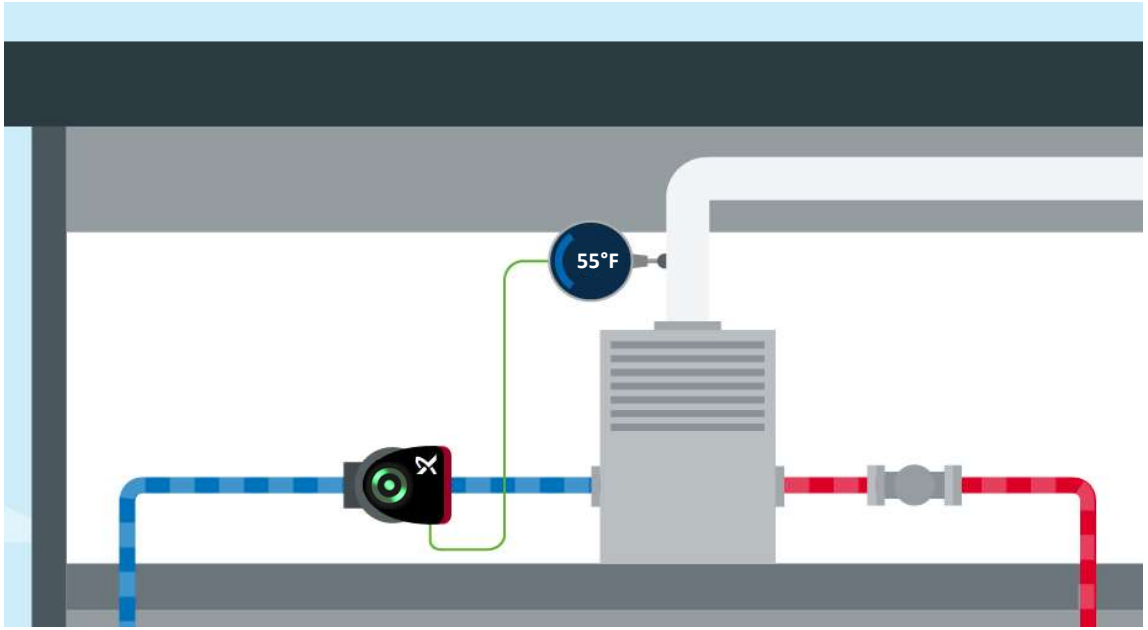


Temperature Reference for Pump
Better control of heat transfer

Supply-Air Temperature
For a Variable-Volume System, maintaining a constant supply-air temperature is our recommended set-up

Return-Air Temperature
For a Constant-Volume System, maintaining a constant return-air temperature is our recommended set-up

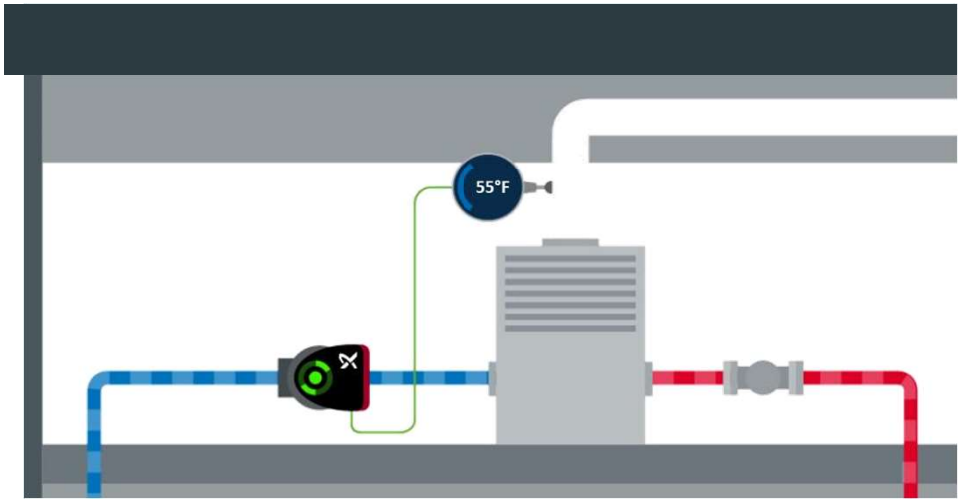
Control via AHU controller
Provide 0-10V signal from AHU controller to pump to proportionately adjust speed



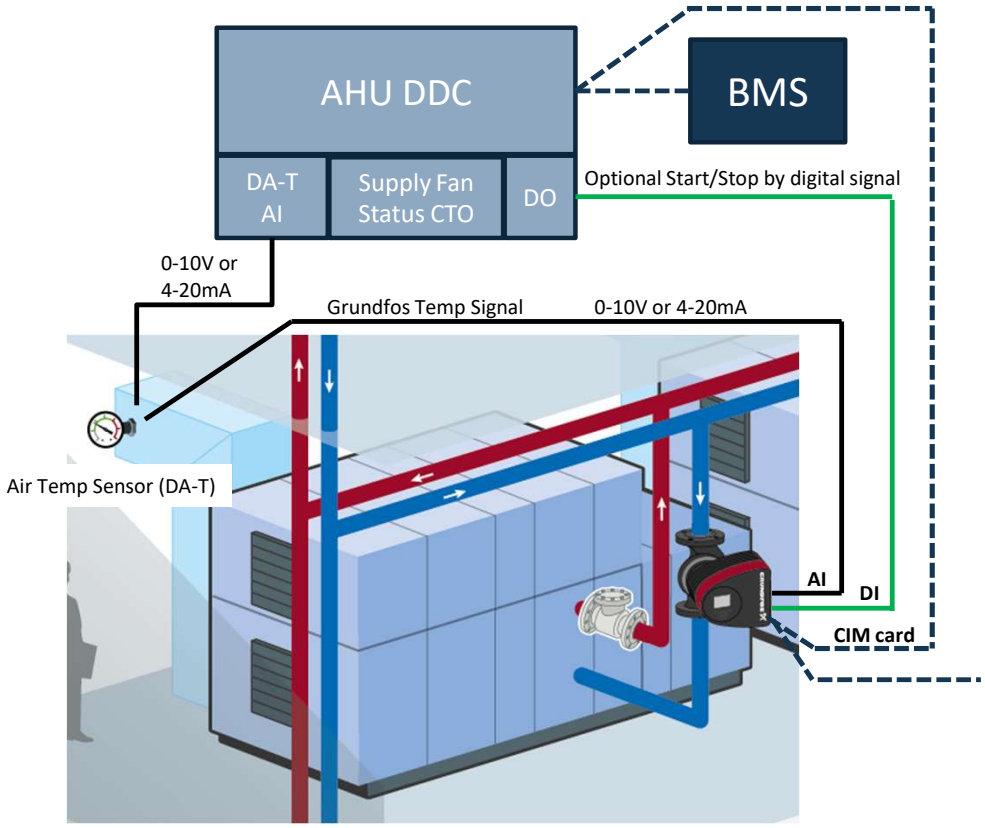
Temperature reference for pump near the air handling units

Automatic balancing

During operation, the distributed pump serving each circuit, continuously measure the air duct temperature and automatically adjust the pump speed to achieve the desired temperature. Each circuit is always being supplied to demand.



Distributed Pump Installation & Control



Magna3 Primary Control – BMS Monitor

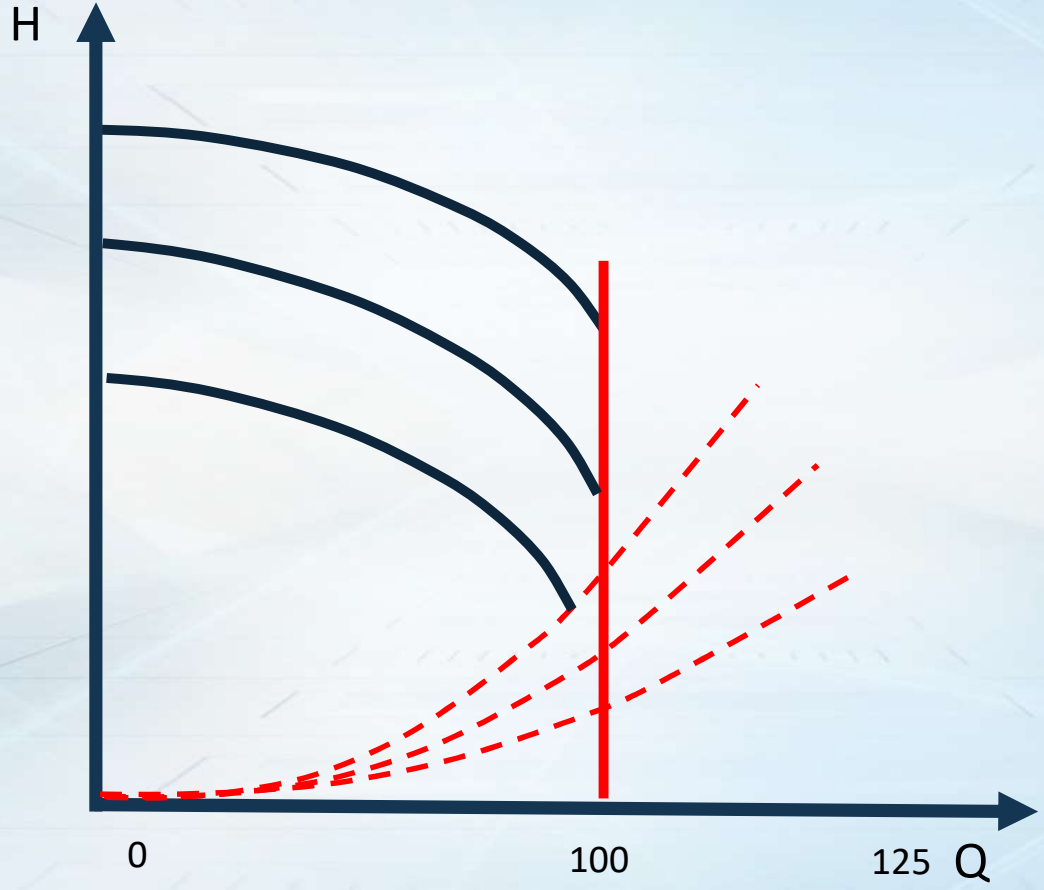
Manga3 Pump	
Subject	**Setting**
SetpointSetpoint (temp) Via BMS/Grundfos Go	DA-T (temp from discharge air)
Operating Mode	Normal
Control Mode	Constant Temp
Flow Limit	Max Q from AHU
Analog Input	Temp signal from external air sensor
Digital Input from DDC	Start/Stop Signal (optional)
External Setpoint Function	If input DI from DDC is not used select “Linear w/Stop”*
BUS Comm	CIM Card

*If the input signal is below 10%, the pump changes to operation mode “stop”. If the signal is increased above 15%, the operating mode is changed back to “Normal”

Low ΔT Syndrome

FLOW*LIMIT*

Example:
Flow*LIMIT* is set at
100 gpm



Temperature Reference for Pump
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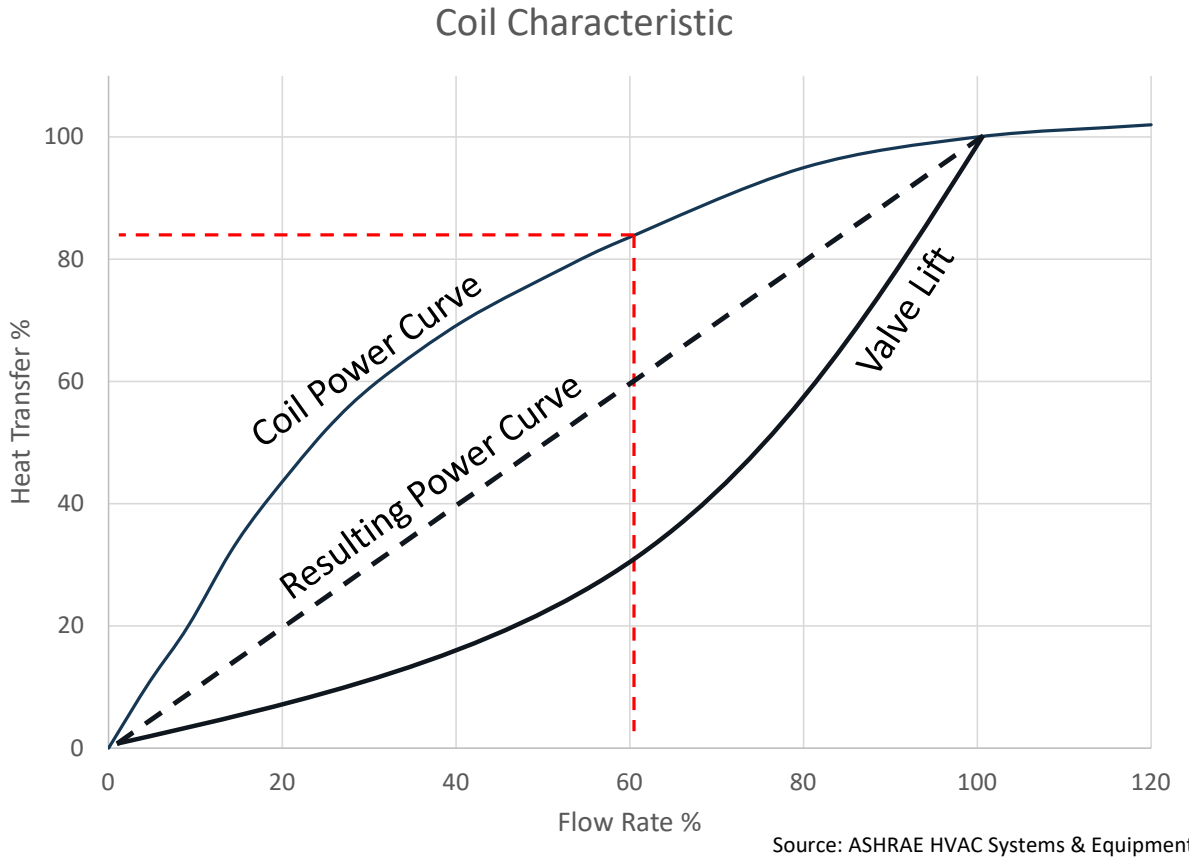
Valve Authority's role
Valve Authority of 1 gives a linear heat transfer if the authority is lower, the controllability is compromised

Distributed Pumping
Pump automatically adjusts the flow to meet the heat load demand



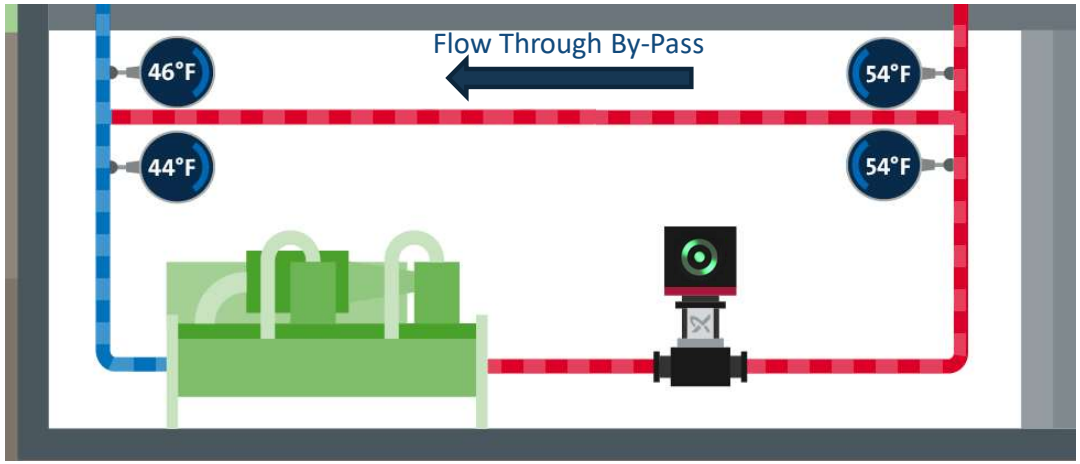
Source: ASHRAE HVAC Systems & Equipment

Balancing of Primary/Secondary Side

Balanced Primary Secondary Side
Temperature across by-pass is equal

Decrease Primary Pump Speed
Supply- is mixed with Return water

Increase Primary Pump Speed
Return- is mixed with Supply water



Deep dive into the two systems

Simulation of 25 floor riser at 50% max flow

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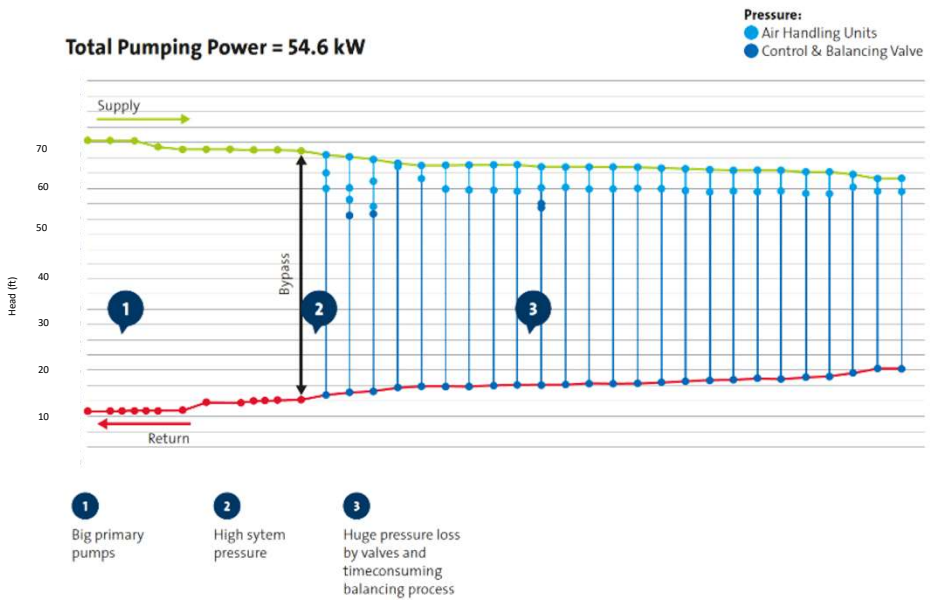
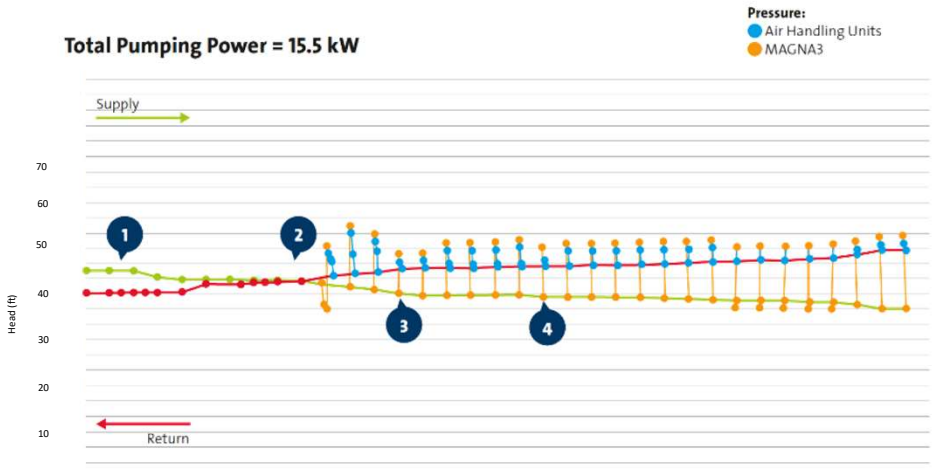
The valve-based chilled water system



1. Big primary pumps
2. High sytem pressure
3. Huge pressure loss by valves and timeconsuming balancing process

Grundfos Distributed Pumping system



1. Small primary pumps
2. Primary/Secondary Bypass/Deco upler Line
3. Low system and differnetial pressure
4. Each pump adjust to heat load

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Energy consumption: Did you know that…

On an average,

30-40%

of energy in a commercial building is consumed by HVAC systems. By becoming more energy efficient in HVAC, commercial buildings can reduce OPEX, increase property asset value and enhance staff comfort.*

*Source: Grundfos

CASE STUDY

Ngee Ann Polytechnic Block 22, Singapore

SITUATION

- Located in Singapore, Block 22 at Ngee Ann Polytechnic (NP) is a mixed-use building housing a cafeteria, sports hall, student lounges and office spaces.
- To uphold its Green Mark Platinum rating and achieve even higher energy savings, they decided to revisit its HVAC system design.
- The goal was to identify ways to push energy savings while maintaining a cool, comfortable environment throughout the building.

THE SOLUTION

- Grundfos' Distributed Pumping solution comprised
  - 15 MAGNA3 Distributed Pumps
  - 4 TPE3 Primary Pumps
  - Grundfos GO REMOTE App
  - Our unique solution expertise

MAGNA3

TPE3

Grundfos GO

Outcome with Grundfos iSOLUTIONS

EASY AND FAST COMMISSIONING

INCREASED DELTA T BY

28%

ENERGY SAVINGS BY

54%

- ✓ The Grundfos MAGNA3 Distributed Pumps **continuously measure** the air duct temperature and **automatically adjust** their pumping speed to achieve the desired temperature
- ✓ The system **auto balances** any load, providing optimal comfort for tenants
- ✓ The retrofitted Grundfos system with MAGNA3 Distributed Pumps **increased Delta T** by 28%
- ✓ Avoiding the valves reduced pumping power from 15 hp to 7.5 hp, resulting in a **total pump energy savings** of 54%

Energy usage comparison

With the detailed engineering completed, it is possible to calculate the energy consumption of all the pumps in the Distributed Pumping solution, and compare this with a conventional variable-primary design. The comparisons are based on the theoretical pumping energy which is calculated from the flow and head.

For the comparison, it is necessary to make assumptions about the load pattern of the building and specify the operational hours, where the HVAC system is in operation. The building load is devided into three flow categories, and a percentage is defined for how often this load occours:

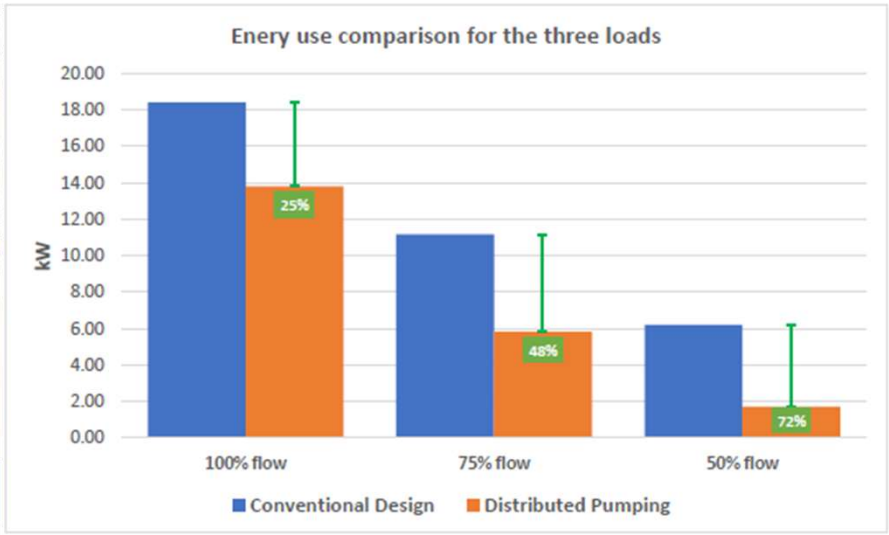
- 100% flow equal to peak load, and accounts for:	1%	of yearly opperation
- 75% flow, and accounts for:	42%	of yearly opperation
- 50% or less flow and accounts for:	57%	of yearly opperation

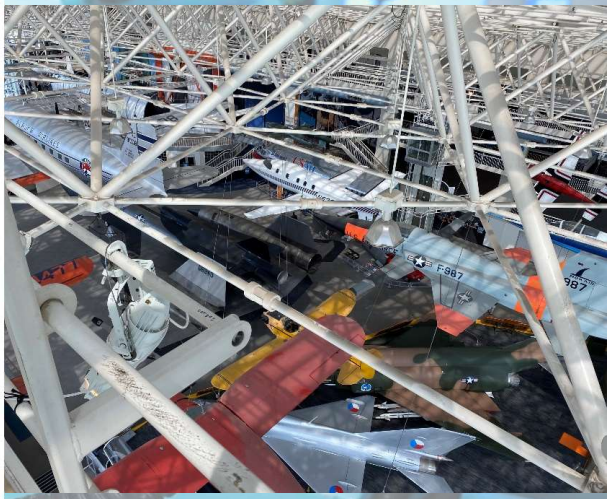
Next the buildings opperational hours are specified in the table below:

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Hours:	14	14	14	14	14	14	14

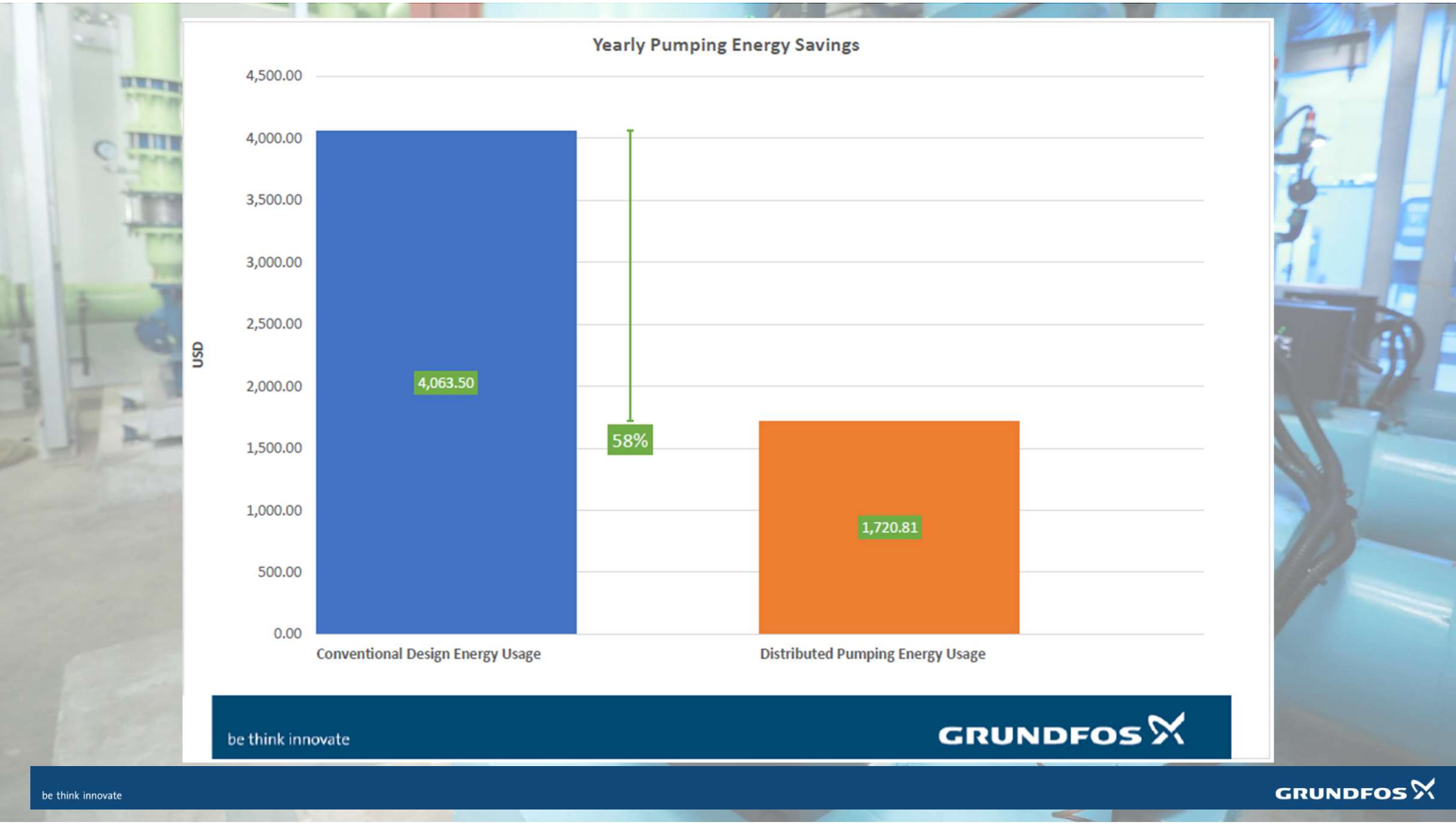
During a year the system is shut off:	20	days
The average electrical price is:	0.1	USD/kWh

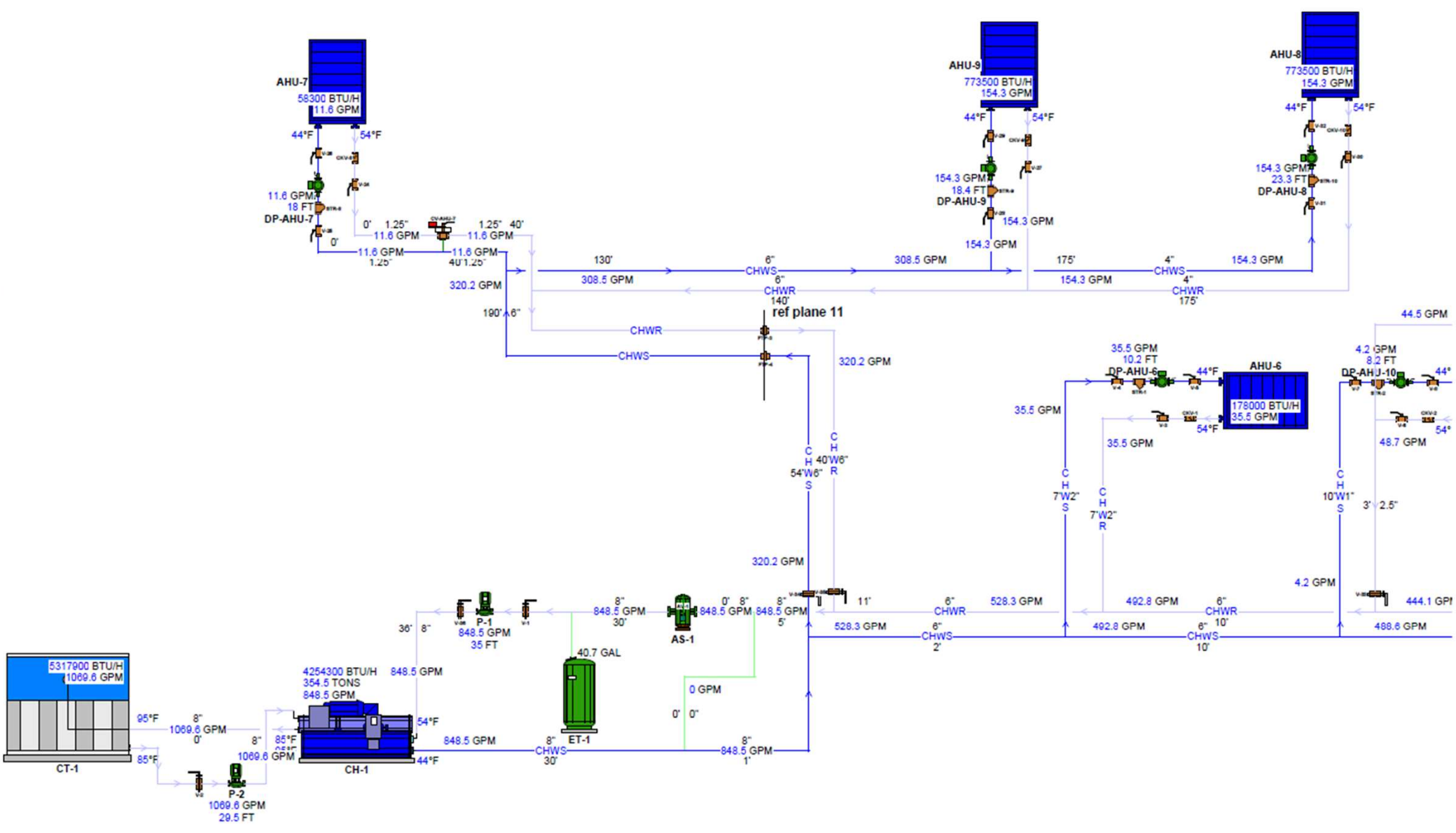
Based on the required flow of the units in the building design, and the calculated pressure drops in the system, the pumping energy usage for distribution of chilled water in the building is plotted in figure 1. at the three defined loads.
The following two pages shows respectively the yearly energy comparison and yearly energy savings



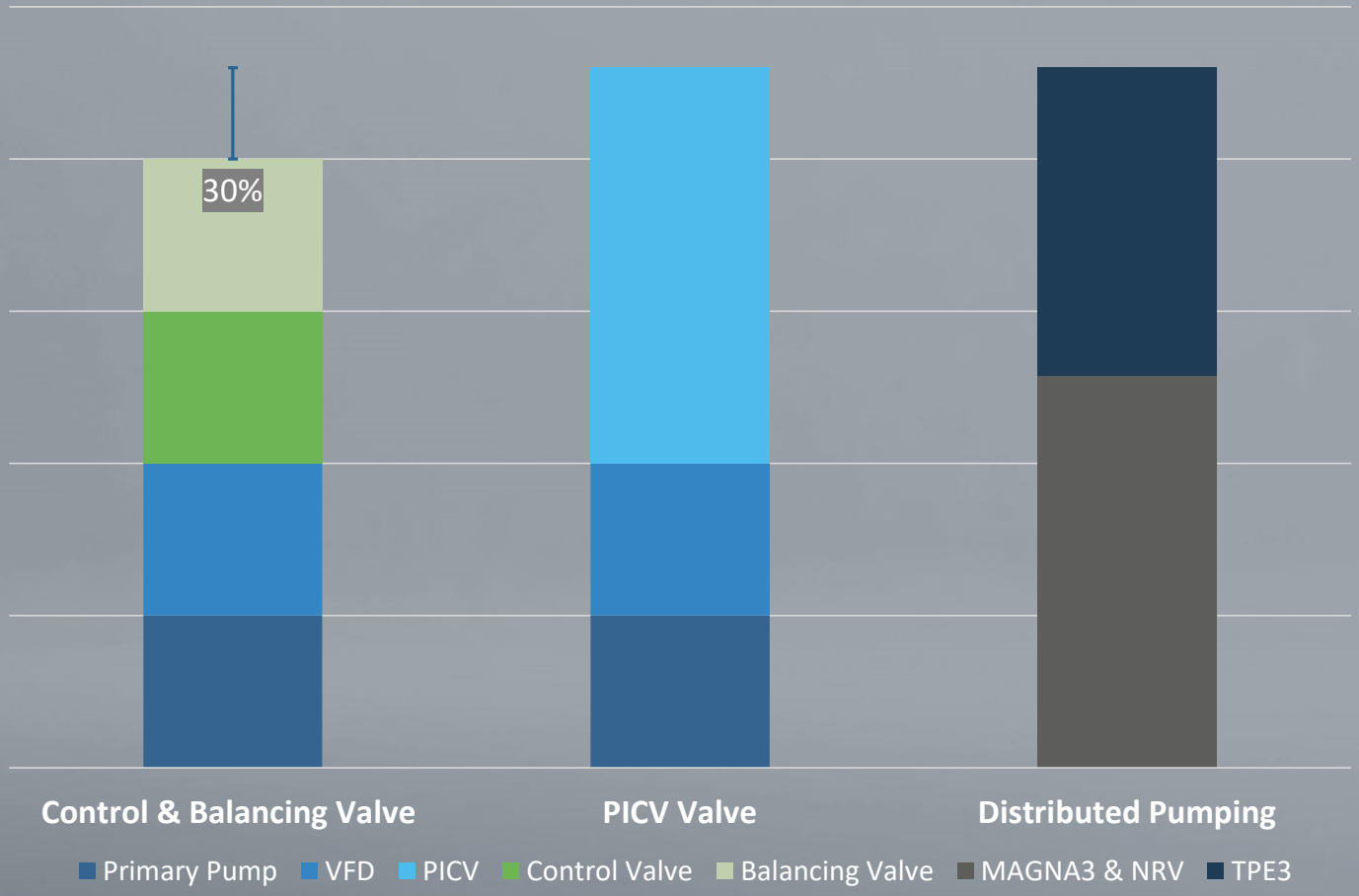



Comparison of Yearly Pumping Energy Use
45,000.00
40,000.00
35,000.00
30,000.00
25,000.00
20,000.00
15,000.00
10,000.00
5,000.00
0.00
kWh
40,634.97
58%
17,208.09
Conventional Design Energy Usage
Distributed Pumping Energy Usage
be think innovate
GRUNDFOS


Yearly Pumping Energy Savings
4,500.00
4,000.00
3,500.00
3,000.00
2,500.00
2,000.00
1,500.00
1,000.00
500.00
0.00
USD
4,063.50
58%
1,720.81
Conventional Design Energy Usage
Distributed Pumping Energy Usage
be think innovate
GRUNDFOS


AHU-7
58300 BTU/H
11.6 GPM
44°F
54°F
11.6 GPM
18 FT
DP-AHU-7
0'
1.25"
11.6 GPM
1.25" 40'
11.6 GPM
11.6 GPM
1.25"
40' 1.25"
320.2 GPM
190' 6"
130'
6"
CHWS
308.5 GPM
6"
CHWR
140'
308.5 GPM
AHU-9
773500 BTU/H
154.3 GPM
44°F
54°F
154.3 GPM
18.4 FT
DP-AHU-9
154.3 GPM
154.3 GPM
175'
4"
CHWS
154.3 GPM
4"
CHWR
175'
154.3 GPM
AHU-8
773500 BTU/H
154.3 GPM
44°F
54°F
154.3 GPM
23.3 FT
DP-AHU-8
ref plane 11
CHWR
CHWS
320.2 GPM
CH 54'W6" S
CH 40'W6" R
320.2 GPM
11'
6"
CHWR
528.3 GPM
528.3 GPM
6"
CHWS
2'
35.5 GPM
10.2 FT
DP-AHU-6
44°F
AHU-6
178000 BTU/H
35.5 GPM
54°F
35.5 GPM
35.5 GPM
CH 7'W2" S
CH 7'W2" R
492.8 GPM
6"
CHWR
10'
492.8 GPM
6"
CHWS
10'
4.2 GPM
8.2 FT
DP-AHU-10
44°
54°
48.7 GPM
44.5 GPM
CH 10'W1" S
3'
2.5"
4.2 GPM
444.1 GPI
488.6 GPM
36'
8"
P-1
848.5 GPM
35 FT
8"
848.5 GPM
30'
0'
8"
848.5 GPM
AS-1
848.5 GPM
8"
848.5 GPM
5'
40.7 GAL
ET-1
0 GPM
0'
0'
8"
848.5 GPM
1'
8"
CHWS
30'
848.5 GPM
5317900 BTU/H
1069.6 GPM
CT-1
95°F
8"
1069.6 GPM
0'
85°F
P-2
1069.6 GPM
29.5 FT
8"
1069.6 GPM
85°F
4254300 BTU/H
354.5 TONS
848.5 GPM
848.5 GPM
54°F
CH-1
44°F

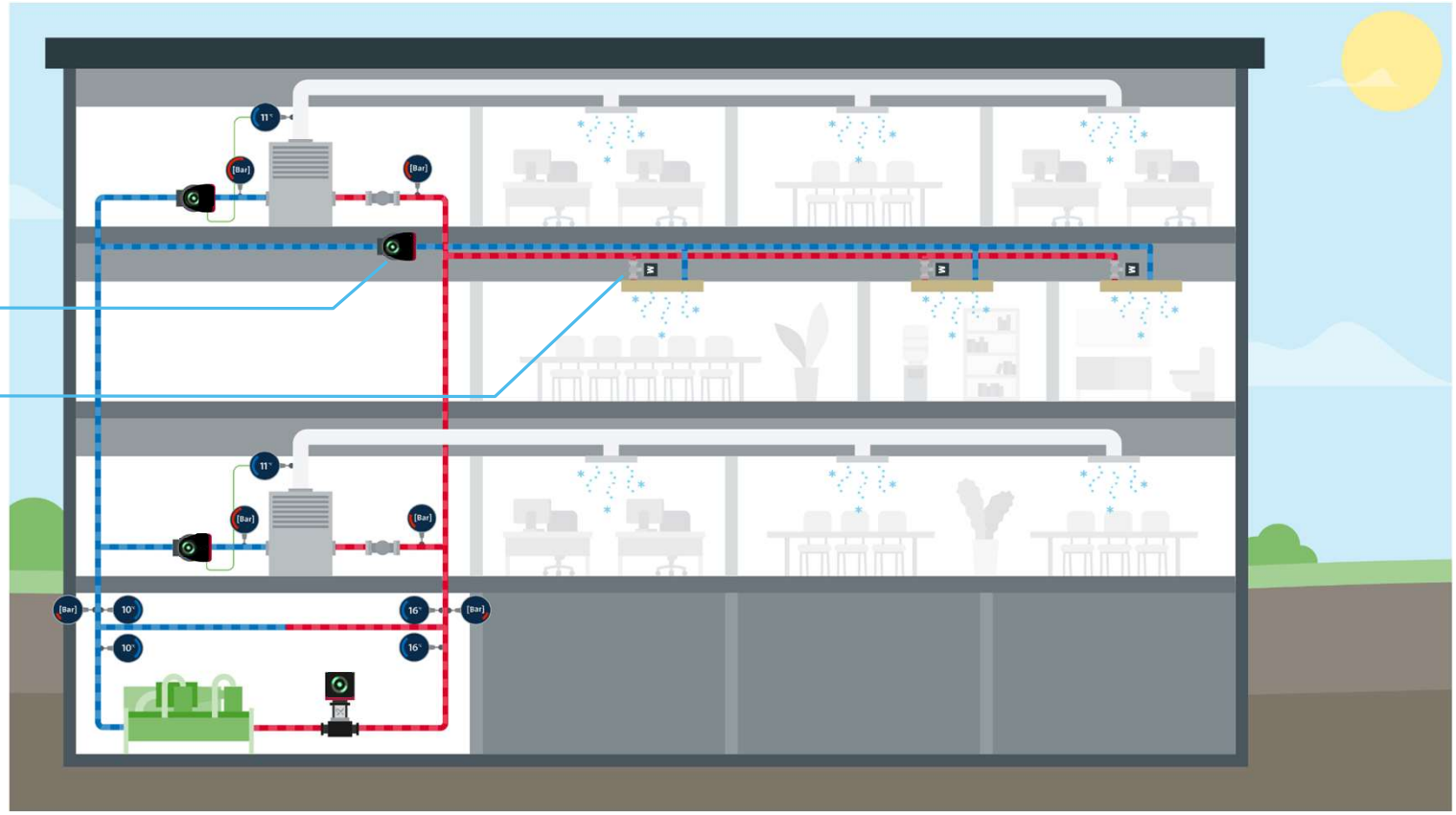
CAPEX Investment comparison



Hybrid System for suppling Fan Coil Units

- The Pump is running in proportional pressure mode
- Automatically adjusts pressure based on number of active fan coil units
- Pump runs at minimum curve if all valves are closed

- Each fan coil is equipped with an ON/OFF valve

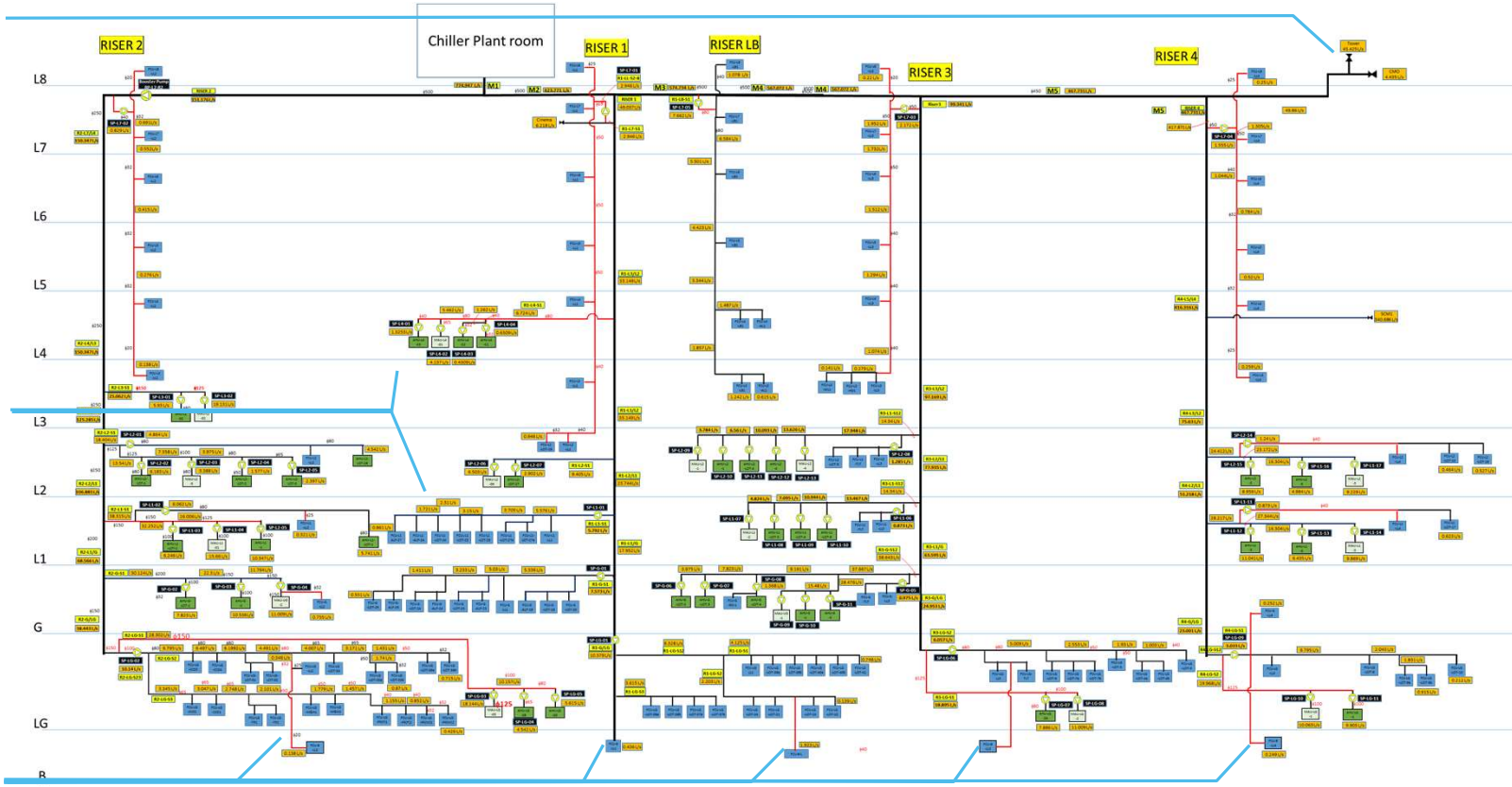


Design Example: Mall

- Easy to expand and won't require recommissioning of existing risers

- Mix between AHU and FCU-zones
- Flow is automatically adjusted to heat load
- No need to do complex and time demanding system balancing of all the risers besides the initial pump commissioning
- Easy to extend a branch of FCU with more FCUs

- No Longer necessary to determine critical pressure point, with Distributed Pumping, everything is decoupled and sized according to flow and pressure demand

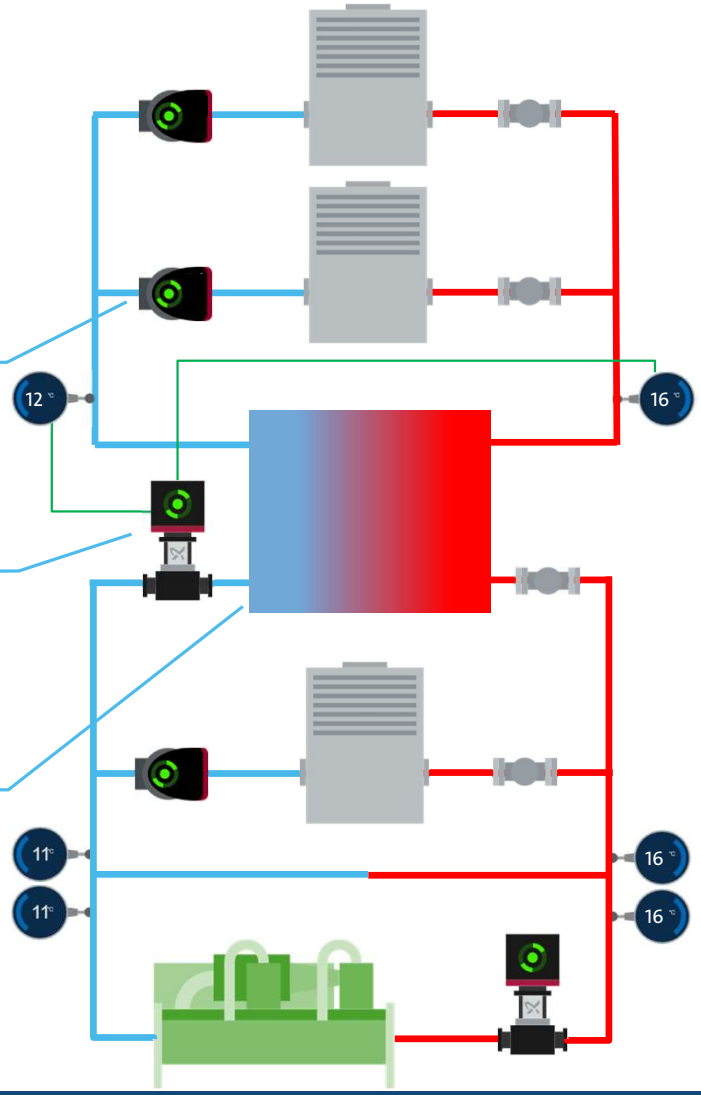


Design Example: High Riser

- The coil pumps will circulate the water in the secondary side of the heat exchanger based on the branch heat load

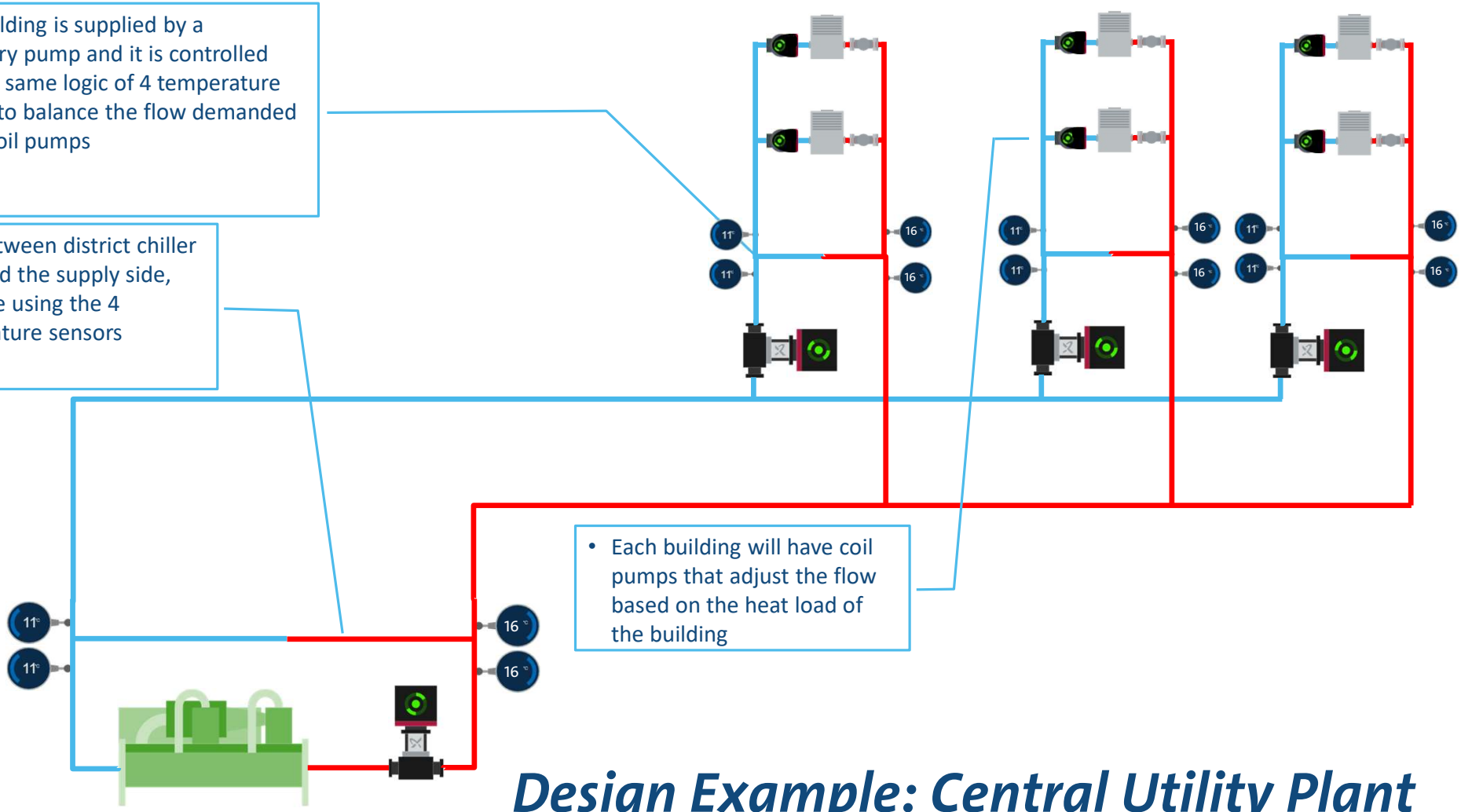
- The heat exchanger supply pump could be controlled with differential temperature control mode and a temperature sensor on the secondary side of the heat exchanger

- To avoid having a high water column pressure, we add a heat exchanger to split the building into individual systems
- This also means all your equipment can have lower PN rating



- Each building is supplied by a secondary pump and it is controlled with the same logic of 4 temperature sensors to balance the flow demanded by the coil pumps

- Flow between district chiller plant and the supply side, are done using the 4 temperature sensors



- Each building will have coil pumps that adjust the flow based on the heat load of the building

Design Example: Central Utility Plant

Who To Contact For More Information

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