DISTRIBUTED PUMPING IN CHILLED WATER SYSTEMS

SAVE UP TO 54% ENERGY

LEARN HOW TO INCREASE END-USER COMFORT, SAVE ENERGY AND IMPROVE DELTA T IN CHILLED WATER SYSTEMS WITH GRUNDFOS DISTRIBUTED PUMPING.

FAST AND EASY **COMMIS-SIONING**

IMPROVED **INDOOR CLIMATE**

UP TO **54%** ENERGY SAVINGS

GRUNDFOS iSOLUTIONS

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Chilled water systems with modulating valves are common air conditioning systems in today's commercial buildings. However, these systems face challenges with balancing and poor dynamic flow regulation, which leads to severe energy loss, inadequate climate control and an often-uncomfortable environment. As a solution to these challenges, distributed pumping solutions are growing in popularity. Replacing valves with pumps on each floor of the building, instead of centralising them in the basement, provides continuous automatic balancing, reducing pump energy consumption and providing a more consistent, comfortable indoor climate.

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Conventional chilled water systems
In chilled water air conditioning systems, the chilled water is typically produced at the chillers in the central utility room and then distributed to various terminal units throughout the building. All chilled water distribution systems (e.g. primary, secondary or primary-secondary) require pumps for moving the chilled water, and all commercial buildings have several terminal units with different needs.

To meet those various needs and properly control the flow and pressure of each terminal unit, balancing and control valves or Pressure Independent Control Valves (PICVs) are used to set and regulate the water loop's various pressure losses. The balancing process is very time consuming and costly, but it is needed to ensure correct flow in the circuits and control the temperature in the coils of the air handling units (AHUs) according to the design set point.

There are several reasons why chilled water loops can get out of balance, such as improper commissioning, components deteriorating over time, aging of the building and changes to other parts of the system installation. An imbalanced water loop can lead to a low Delta T (ΔT), causing the chillers to work outside the best efficiency point (BEP) and over pumping the loop. This leads to excessive energy consumption and can result in an uncomfortable environment.

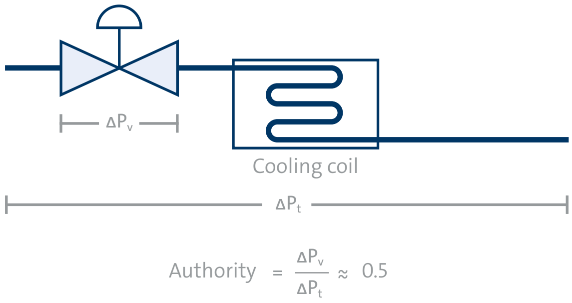
How imbalanced water loops lead to excessive energy consumption
During the balancing process, the balancing valves are adjusted to compensate for the various pressure losses in each loop. This helps to create a fair distribution of the chilled water into the terminal units located at each circuit. In order to have a functional and reliable system, the system components need to be correctly sized to meet the building's cooling load.

Correct sizing of control valves, for example, requires that they have correct valve authority. The standard recommendation is to select a control valve size whose authority is never less than 0.5. (See equation.)

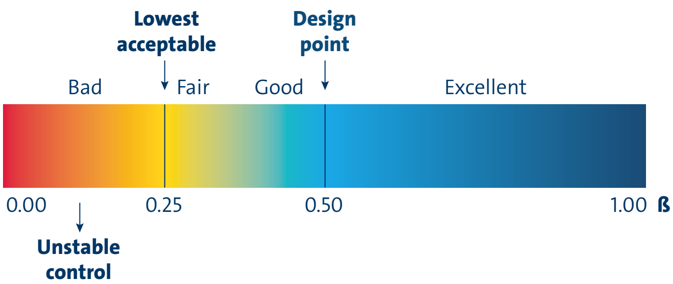
$$N = \Delta P_{valve} / \Delta P_{total}$$

N	is the valve authority
ΔP_{valve}	is the pressure drop across the valve in the fully open position
ΔP_{total}	is the total pressure drop across the circuit

Valve authority



An oversized valve (valve authority below 0.25) can reduce functionality and reliability and create excessive energy consumption on the total system level.



Low Delta T syndrome means the chilled water system cannot maintain the design levels of Delta T. This is typically caused by a mismatch between the load and the needed flow, which leads to non-fully loaded chillers and staging further chillers in an attempt to bring the Delta T back to design levels.

Several causes of the low Delta T syndrome are directly linked to improper valve sizing and valve control. Other common causes that amplify this problem are, for example, improper coil selection and dirty filters in the terminal units, which causes improper heat transfer[1].
In any case, low Delta T results in the running of too many chillers or operating them outside BEP, over pumping the system and operating outside the design criteria. This leads to excessive energy costs.

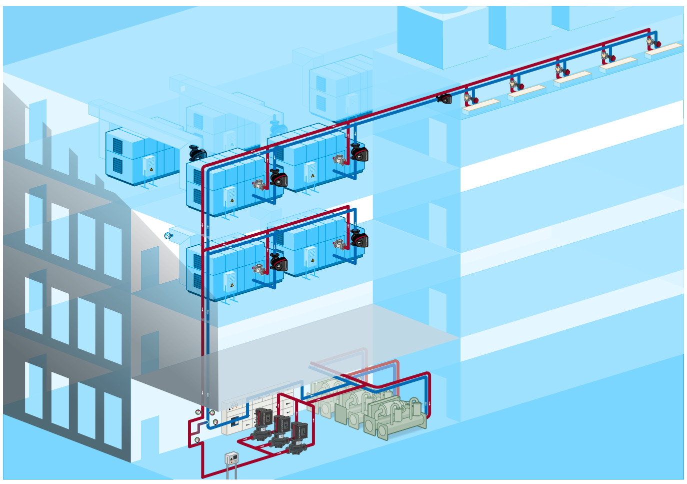
[1] *Degrading Chilled Water Plant Delta-T: Causes and Mitigation by Steven Taylor*

The pros and cons of Pressure Independent Control Valves
Pressure Independent Control Valves (PICVs) are one solution to low Delta T syndrome. Compared to separate balance and control valves, electronic PICVs ease the initial balancing process and improve dynamic balancing during operation. The latest valve generations for balancing and control have added features to further improve the balancing and low Delta T issues, but they come with added complexity. A higher number of integrated components increases the risk of failures and the cost of ownership dramatically – and the valves continue to throttle the flow, creating pressure loss that must be compensated by additional pump energy.

The holistic solution to imbalanced water loops: distributed pumping
Distributed pumping solutions are a paradigm shift away from centralised pumps in distribution networks towards decentralised pumps distributed throughout the building. By replacing balancing and motorised valves with pumps, the system is equipped only with components that generate pressure only when and where it is needed.

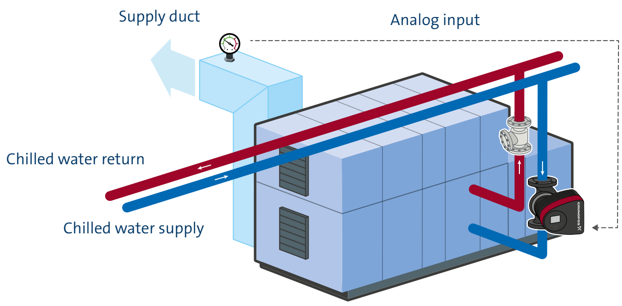
This reduces the time spent on balancing the system, as once the correctly sized pumps are selected, there are no valves needed to balance the system. Additionally, the main pumps can be downsized as distributed pumps generate the needed pressure individually, saving pump energy that way as well.

Distributed pumping solutions can be applied to existing chilled water systems that need refurbishment or to new commercial buildings planned with chilled water air conditioning. Grundfos uses MAGNA3 pumps to replace the balancing and control valves. (See figure.) MAGNA3 pumps have proven their reliability in HVAC applications for many years as maintenance-free wet-runner pumps.



How distributed pumping works
Distributed pumping systems consist of five key components: primary pumps, distributed pumps, primary pump controller, check valves and sensors located throughout the building. The primary pump controller uses a control algorithm to manage the primary pumps, which are variable speed pumps that are regulated by sensor measurements from the decoupled line to avoid over or under pumping the system.

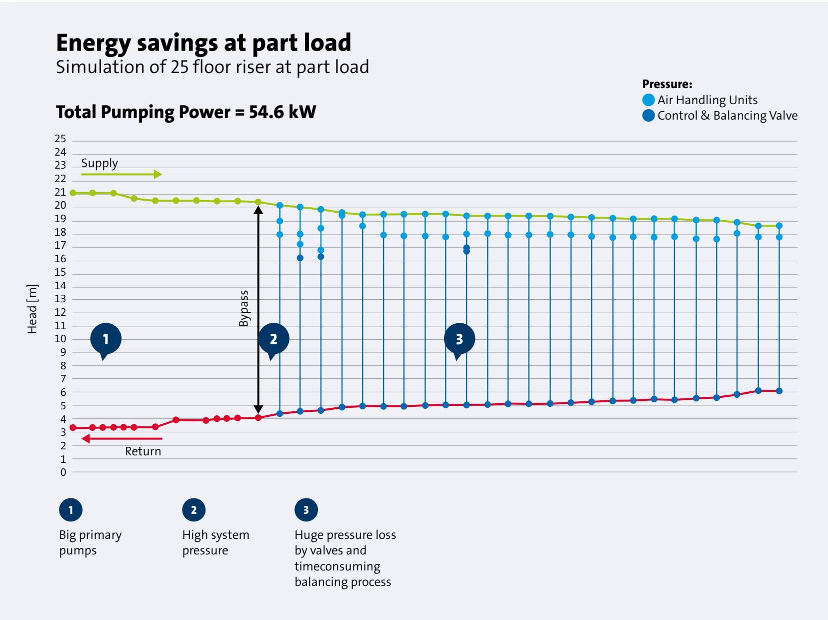
Dedicated distributed pumps are installed with a non-return valve at each air handling unit (AHU). The non-return valve prevents backflow in case the AHU must be shut down. The distributed pumps measure the air temperature using the AHU air duct sensor and will automatically regulate the speed to achieve the desired temperature. Interfaces with the building management system (BMS), if installed, and other control options can be discussed during the design process, ensuring seamless integration based on the sequence of operations.

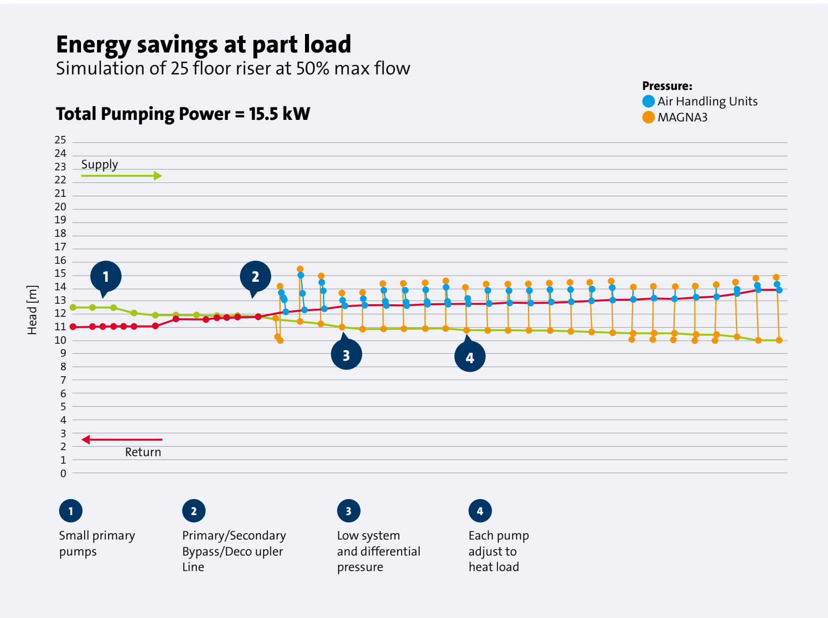


In the scenario where most of the cooling load is provided by fan coil units (FCUs), a feasibility study could be conducted to decide the appropriate design, considering commercial aspects as well.

Comparing pressure gradients between the two systems
In the below figure we can see the simulation of a pressure gradient for a conventional (Variable Primary Only) HVAC system. The graph shows that the overall pressure required to overcome the friction losses for the critical loop is very high (the difference between the red and blue lines). This creates a demand for higher pump power. Also, the non-critical loops require less pressure and will throttle the excess pressure in valves (purple line), which results in excess energy consumption.

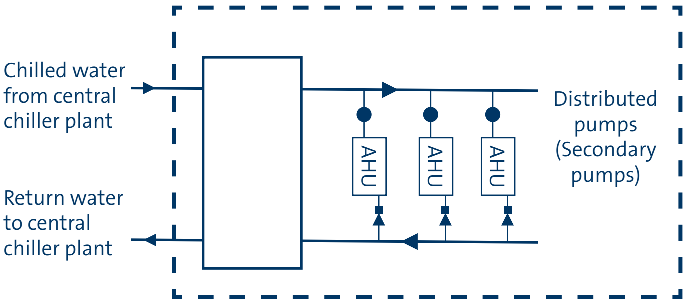
Distributed pumping offers a completely different picture on the pressure diagram for the same system. In one example of a Grundfos Distributed Pumping solution (see below figure), the overall pressure is significantly lower as each pump generates only the amount of pressure that is needed each time (the difference between the red and blue lines). The valves have been removed completely from the system leaving only the AHU coils as the main source of pressure drop. This design results in much lower energy usage and lower total expenditures.





District energy systems
In district cooling systems, actual cooling only happens on the secondary side of the building. As the distributed pumps do all necessary pumping and control on the secondary side, the entire system can be simplified. (See figure.)

District energy systems

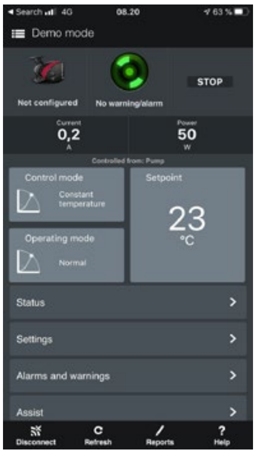


Case: Block 22 reduces pump energy consumption of its chilled water loop by 54%
Located in Singapore, Block 22 is a mixed-use building housing a cafeteria, sports hall, student lounges and office spaces. The Singapore Building Construction Authority has certified Block 22 as a Green Mark Platinum building. The building uses a Grundfos Distributed Pumping system in a chilled water loop to cool a total area of approximately 6000m², reducing the building's energy consumption by 54%.

Consisting of 10 AHUs and five FCUs, the building's air conditioning system is served by three chillers with a total cooling capacity of 570 RT (2005 kW). The system is configured with two working chillers and one chiller as standby. Four chilled water pumps were originally installed to distribute the chilled water in the facility in a Variable Primary Only System.

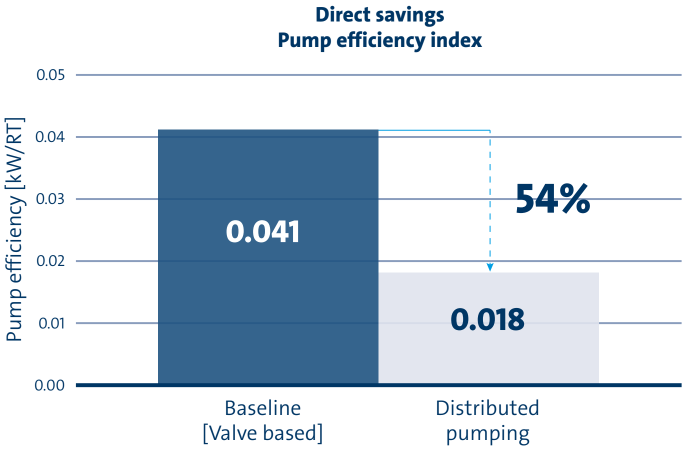
Before the Distributed Pumping system was applied, a baseline measurement for cooling tonnage and total energy consumption for the chilled water loop was made over a six-week period. This included weather data to be able to normalise data when determining a benchmark for the Distributed Pumping solution.

During the installation of the system, the commissioning process was extremely efficient. The initial pump setting was done via the Grundfos GO REMOTE app and the flow limits for the terminal units were adjusted directly in the BMS for each pump. This delivered significant time savings compared to using traditional balancing valves, control valves or PICVs.

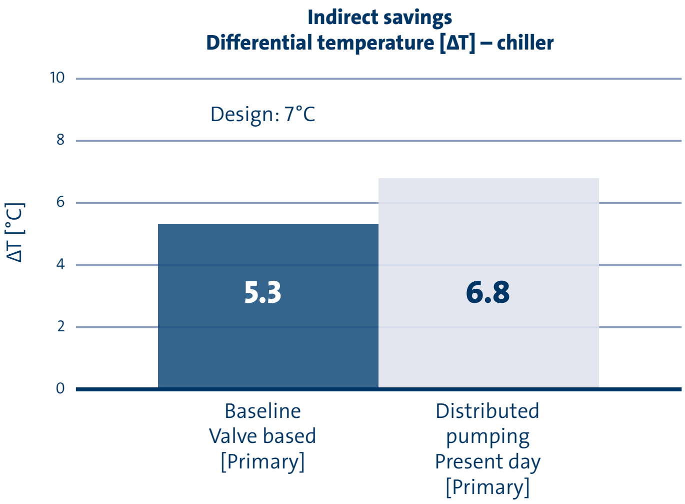


During operation, the Distributed Pumps continuously measure the air duct temperature and automatically adjust the pump speed to achieve the desired temperature – the system is auto balancing any load, providing optimal comfort for tenants.

Reducing the pressure-consuming devices and, in this case, replacing the balance and control valves with Distributed Pumps, reduced the total pump energy consumption for the chilled water loop by 54%.



The design Delta T of Block 22 is 7 °C. Before the Distributed Pumping concept, its Delta T was 5.3 °C, which increased to 6.8 °C after introducing the Distributed Pumping concept.



This is equal to chiller savings if the chillers will be working in their best efficiency point (BEP).

A well-balanced loop system creates a well-balanced indoor climate

Grundfos Distributed Pump system has significant advantages to all stakeholders in the building:

- **AUTOMATICALLY BALANCED AT ANY LOAD** – creating perfect comfort for tenants
- **EASY & FAST COMMISSIONING** – reducing investment
- **PUMP AND CHILLER ENERGY SAVING** – reducing operational expenditures

New energy-saving valves, such as PIVCs, have several valuable functionalities, but valves are still a throttling device creating pressure and energy loss in chilled water systems. Distributed pumping solutions represent a new paradigm in chilled water air conditioning. By providing consistent, accurate load balancing, distributed pumping solutions save energy and provide optimal comfort for people in the building. They are also fast and easy to commission, reducing the initial investment and the time spent on system balancing. For all these reasons and more, distributed pumping is becoming widely spread in commercial building projects around the world.

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