Belimo Energy Valve™

Application Guide

Visit
belimo.com/energy-valve

BELIMO®

General Information

This is the Belimo Energy Valve™ application guide, a central source of information for the planning, selection, and application of the Belimo Energy Valve™. It is intended to provide educational and practical support on this flagship Belimo product to consulting engineers, system integrators, HVAC contractors, commissioning engineers, facility managers and building owners worldwide. Belimo Energy Valve™ is a registered trademark of Belimo. For easier reading, it is referred to as Energy Valve or EV throughout this guide.

In this guide, you will find information on:

- The evolution of valve technology
- The difference between pressure dependent and independent technology
- Mechanical versus electronic pressure independent technology
- An overview of the Energy Valve and its features
- Common applications
- Best practices, including installation and commissioning tips
- Supporting tools, resources and FAQs

TABLE OF CONTENTS

PART A	Introduction to the Belimo Energy Valve™	4
PART B	Belimo Energy Valve™ HVAC Applications	62
PART C	Installation and Configuration	116

This reference guide can be printed on demand or downloaded. This guide serves as a go-to resource for standard questions and solutions, to help increase your knowledge of the Belimo Energy Valve™ and its most common applications. However, it does not replace professional engineering work. If issues that are more complex arise, please contact your local Belimo salesperson or use the Belimo support hotline (**see www.belimo.com**).

PART A

Introduction to the Belimo Energy Valve™

OVERVIEW OF KEY FUNCTIONS AND FEATURES

1	Evolution of Control Valves	6
2	Pressure Independent Valve Technology	10
3	What is a Belimo Energy Valve™?	20
4	Control Modes of the Belimo Energy Valve™	30
5	Feature Overview of the new Belimo Energy Valve™ 4	50

1

Evolution of Control Valves

Control valve technology has significantly evolved over the last two decades. From simple actuation on a valve, to the realm of truly smart valves. Smart valves do more than simply position; they have various flow and/or temperature sensors installed within the valve body, and/or in the air or water stream.

The combination of valve, actuator and sensors allows the smart valve to automate many processes that would be difficult or time consuming to put into a DDC controller.

1.1 Characterized Control Valve (CCV)

Globe valves have dominated the HVAC control valve market for decades but, in 1999, Belimo released its **Characterized Control Valve (CCV)**. It was one of the first products to offer accurate reproduction of the equal percentage curve, overcoming the problem of low flow rates experienced by other valves. The CCV is also 'air bubble tight', meaning it does not permit any water to pass or leak through the valve when closed. The CCV continues to be the best-selling control valve on the market, with millions sold worldwide.

Figure 1: CCV

1.2 Pressure Independent Characterized Control Valve (PICCV)

In 2003, the first **Pressure Independent Characterized Control Valve (PICCV)** made exclusively for the HVAC industry was born. Using the same valve technology found in the CCV, a robust mechanical pressure regulator was integrated to absorb pressure changes in the system. This allowed the desired flow to remain constant despite system pressure changes.

Figure 2: PICCV

1.3 Electronic Pressure Independent Valve (ePIV)

In 2012, Belimo brought the groundbreaking **electronic Pressure Independent Valve (ePIV)** to the market, after four years of development. For the first time, true flow measurement was available on a valve. The ePIV combines an accurate wet calibrated ultrasonic flow meter with a characterised control valve in one device. This combination allows for precise control of the flow with the capability to read the actual flow at all times.

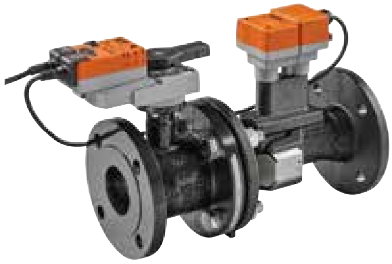


Figure 3: ePIV

1.4 Belimo Energy Valve™ (EV)

In 2010, the first version of the **Belimo Energy Valve™ (EV)** was introduced. The EV is an enhancement of the ePIV, with temperature sensors – in the supply and return water – to measure the **differential temperature** (known as delta T) across the coil or heat exchanger. This, with the built-in software, allows the valve to continually monitor and enhance the efficiency of the heat exchange, avoiding costly and inefficient overflow.

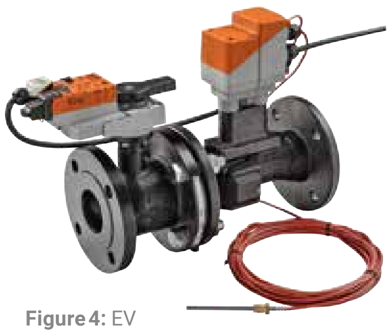


Figure 4: EV

The Energy Valve opened a new chapter with advanced connectivity. Besides the analogue and bus interfaces, and supporting Modbus and BACnet protocols, the EV – also for the first time – included an embedded web server, which simplifies mechanical and electrical commissioning. The EV also includes the capability to securely connect to the internet, and has become the industry's first **Internet of Things (IoT) control valve**.

BELIMO

1.5 Quick Compact Valve (QCV)

In 2013, the ZoneTight™ **QCV** for zone applications was introduced, allowing more accurate control of low flows. This combines the Belimo 'air bubble tight' ball valve design and an extremely low power electrical consumption actuator with quick pop up mounting.

Figure 5: QCV

1.6 Pressure Independent Quick Compact Valve (PIQCV)

In 2016, the ZoneTight product family became **pressure independent**. The **PIQCV** combined mechanical pressure independent and ZoneTight technology for zone applications.

Figure 6: PIQCV

1.7 Belimo Energy Valve™ 4 – bringing together what belongs together

In 2021, a new range of certified thermal energy meters and the Belimo Energy Valve™ 4 was launched. It offers seamless and direct integration to building management system (BMS) or a 3rd party building IoT platform, and provides valuable data on current operation modes, temperatures, flows or energy consumption, which can be directly used for tenant billing.

All these Belimo innovations have helped to solve severe problems and inefficiencies in the hydronic control of HVAC systems, including leaking valves, discomfort from pressure fluctuations, and of course, the low delta T problem.

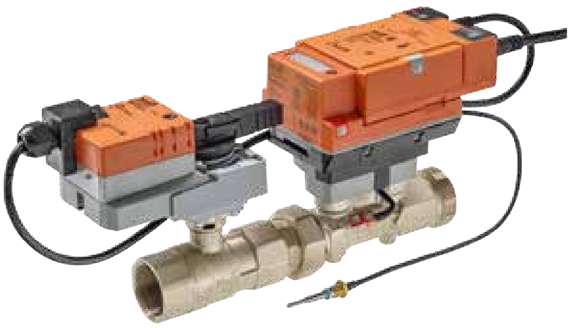


Figure 7: New EV 4

Pro Tip

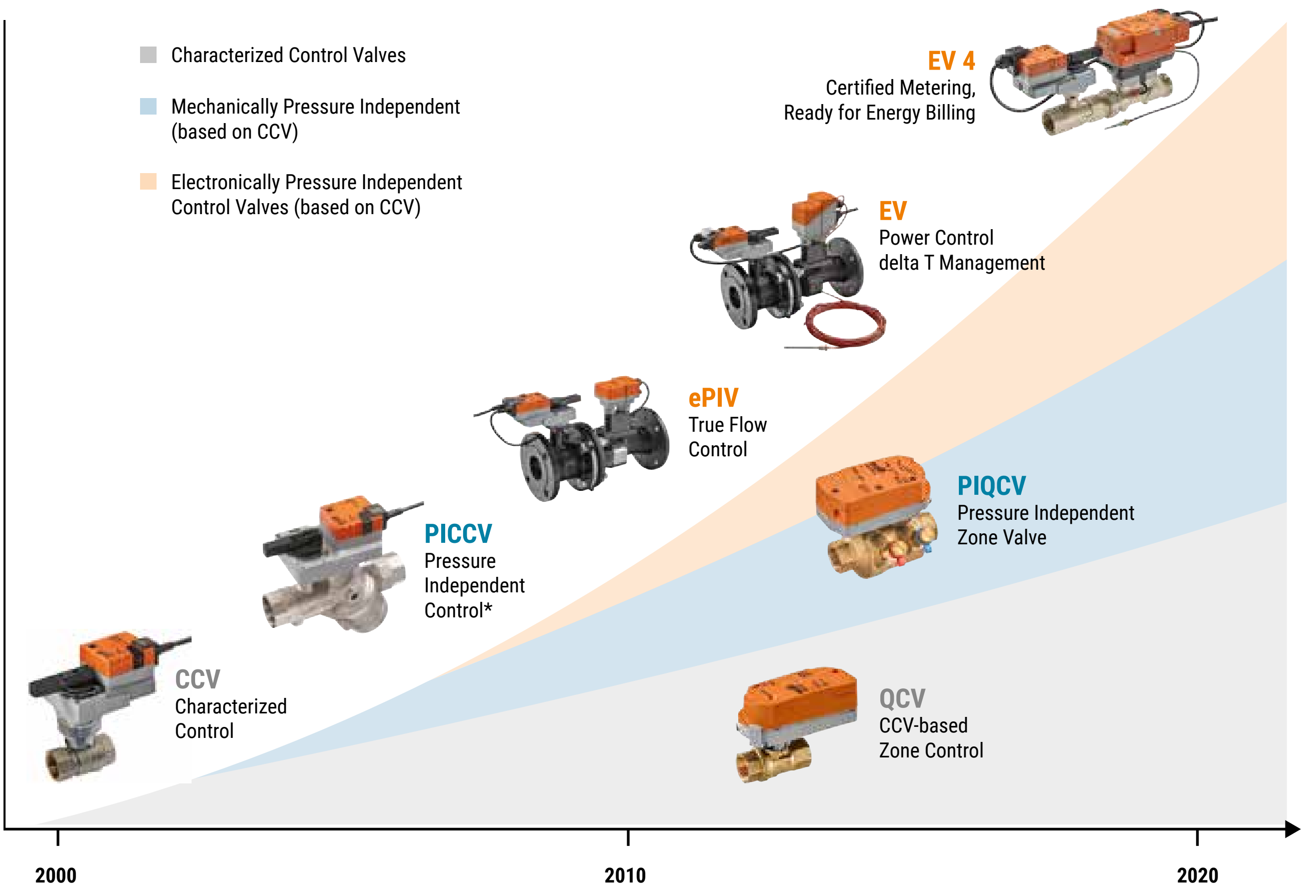
Retrofit of outdated valve and actuator technology is the first step to energy efficiency. Combining the latest leak-free, pressure independent valve with modern, efficient variable speed pumps, significantly reduces power consumption, while increasing occupant comfort. Consult your local Belimo representative for assistance.

1.8 Belimo set the new industry standard twice, for innovative valve and actuator technology

CCV and Zone Valves: In the space of just 10 years, Belimo had clearly established the new industry standard for control valves with the Characterized Control Valve (CCV). From 2013, ZoneTight QCV also initiated an exponential growth spurt, with high volumes for zone applications. It is foreseeable that in the coming decade, a large number of outdated short-stroke zone valves will be replaced by energy-efficient and 'air bubble tight' Belimo QCV zone valves.

PI Valves: Pressure independent valves have experienced exponential growth over the last 5 years. This is driven by compact, mechanically pressure independent PIQCV zone valves, which are replacing the pressure dependent short-stroke valves that are outdated in many applications. However, the fast market penetration of electronic pressure independent valves, such as the ePIV and EV, continues; they will quickly become the industry standard.

For those looking to save energy without sacrificing comfort, the concept of the smart valve has been embraced by the market. From 2012 to 2021, Belimo has sold several hundred thousand ePIVs and EVs, and both product lines continue to grow at very high rates.



*PICCV has since been replaced by PIQCV and ePIV

2

Pressure Independent Valve Technology

The drive towards greater HVAC efficiency led to variable pumping systems and two-port control valves, therefore requiring control valves to operate under dynamic conditions. However, control valves remained sized to static design conditions, making valve selection, balancing and control problematic. To address this, Belimo released the first pressure independent valve designed for the HVAC industry.

2.1 The traditional approach

Pressure dependent valves

In a pressure dependent system, the typical arrangement consists of a manual balancing valve in series with a pressure dependent control valve (globe valve, characterised control valve, zone valve, etc.). Typically, the balancing valves have a machined orifice, or venturi, which allows the technician to measure differential pressure (known as delta P) to obtain the flow value. The flow is obtained either by calculating the delta P and the valve's coefficient (Cv/Kv), or by using flow/delta P tables provided by the valve manufacturer.

Although variable flow systems save building operators substantial pump energy cost every year, complex flow issues caused by pressure fluctuations can arise, resulting in system instabilities. Even the best designed systems still make it challenging to optimise operations, especially during part load.

Pressure dependent valves can suffer from overflow and underflow due to mechanical pressure changes in the system.

2.2 Pressure independent valves

Maintain the flow, independent of pressure fluctuations

Since 2003, when Belimo invented the first Pressure Independent Control Valve, these valves – often referred to as PI Valves, PIV or PICV – have seriously disrupted the way in which building HVAC systems are designed, installed and commissioned. They offer savings at virtually every stage of a project life cycle.

For nearly two decades, pressure independent valves have demonstrated the ability to mitigate costly problems associated with pressure dependent systems. This has provided huge improvements in flow consistency irrespective of system pressure fluctuations. PI valves maintain flow through each coil, only permitting flow changes when commanded by the control signal DDC. As a result, heat exchanger performance is unaffected by system pressure fluctuations.

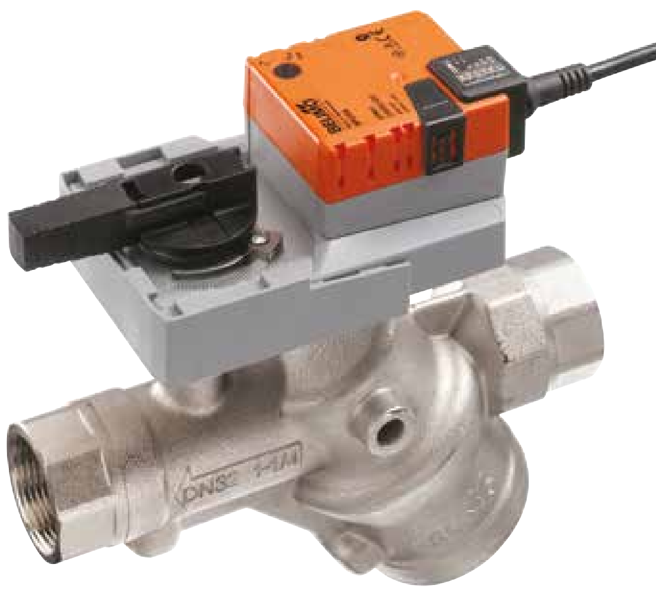


Figure 8: PICCV, the first Belimo pressure independent valve

2.3 Mechanical PI valves

The key components

A mechanical PI valve, sometimes also referred to as a dual valve, combines a control valve with a differential pressure regulator. The pressure regulator keeps a constant pressure across the control valve, resulting in a known flow for a known position. As shown in figure 9, the supply or outlet pressure can be measured at the blue port. These integrated pressure and temperature ports, referred to as 'PT ports', allow measurements during operation.

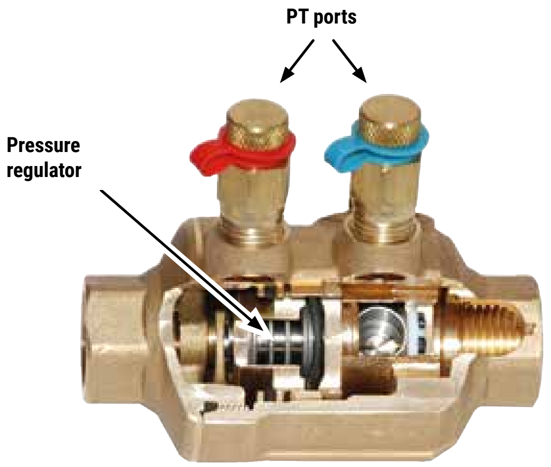


Figure 9: Components of a mechanical PI valve, eg. a PIQCV

How mechanical PI valves work

PI valves require a minimum differential pressure to operate. This differential pressure is required to load the spring, which positions the diaphragm. If a hydronic system provides a differential pressure below this minimum, the pressure regulator mechanism is unable to respond to pressure changes effectively, making the valve pressure dependent and causing it to deliver inconsistent results. If the maximum differential pressure rating of the valve is exceeded, the diaphragm will be experiencing additional stress, which can damage the regulator if left for extended periods. Usually, hydronic systems are designed such that they deliver the differential pressure within the required range, with little or no additional equipment or design overhead.

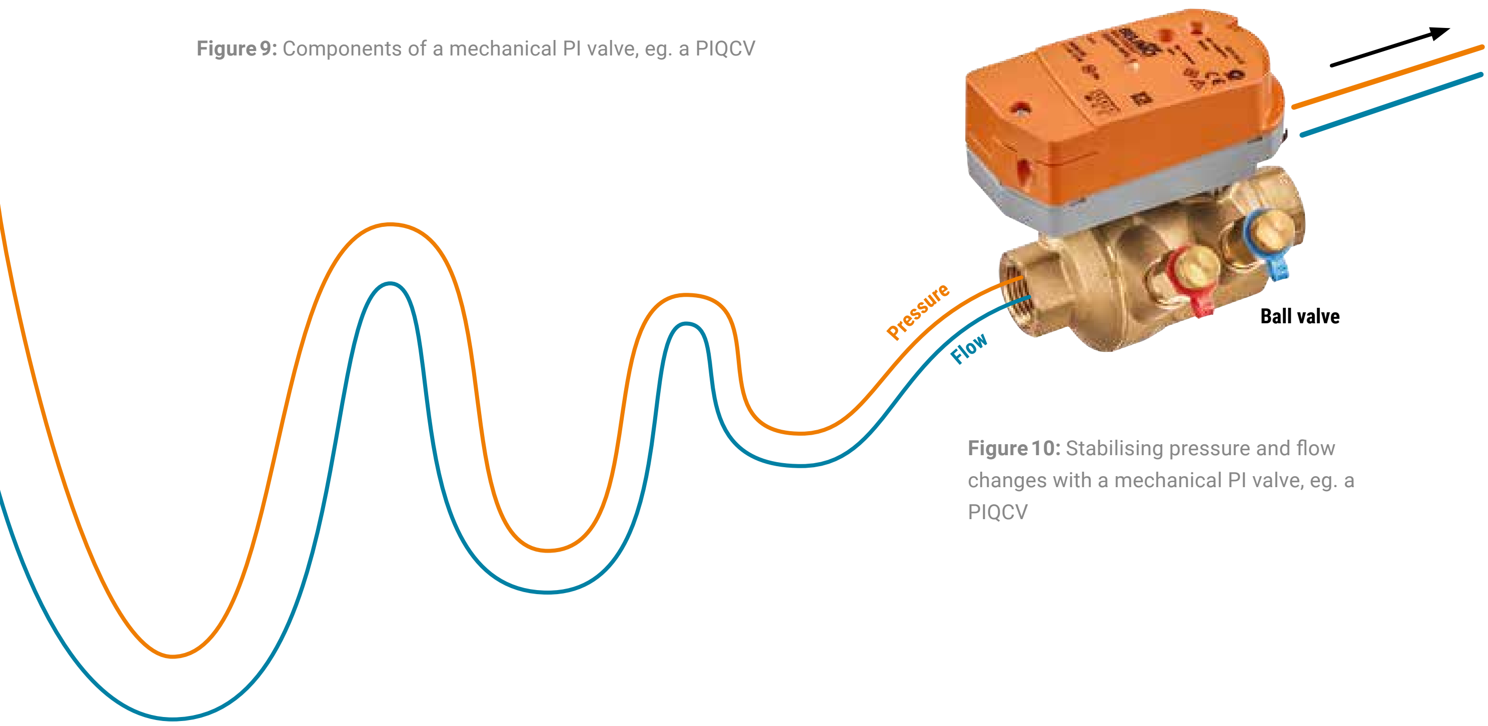


Figure 10: Stabilising pressure and flow changes with a mechanical PI valve, eg. a PIQCV

Advantages of mechanical PI valves over pressure dependent valves
By controlling flow and eliminating the effects of pressure fluctuations, pressure independent valves eliminate the need for extra balancing valves. Incorporating the balancing function into the control valve not only minimises installation cost, but also substantially reduces commissioning cost due to the elimination of the labour-intensive balancing process. PI valves can arrive to the job site pre-set to design flow, so there is no additional setup required. They can also arrive set to the full flow position, to allow higher flushing velocities before being set to design flow.

Occupant comfort, installation simplicity and ongoing flexibility have been the key to the success of the mechanical PI valve. PI valves are selected on flow, and do not require flow coefficient or valve authority calculations. Changes to the building's existing hydronic system doesn't effect PI valves avoiding costly re-balancing or comfort issues arising from not re-balancing.

Value added to the system with PI valves
Building owners realise the benefits of PI valves with energy savings and increased occupant comfort. Installers save significant amounts of labour by not installing balancing valves and a reduced commissioning programme.

In summary, pressure independent valves stabilise the control of variable flow systems, offering greater efficiency and worry-free, dynamic balancing, therefore making installation and commissioning a significantly easier task.

Challenges with mechanical PI valves
If you wish to measure the flow through the valve, you need an additional device such as a machined orifice or venturi. While many PI valves are equipped with PT ports, they should only be used for the measurement of differential pressure. Pressure drop across the PI valve body isn't suitable for flow calculations, as its geometry moves with the regulator as a result of pressure changes. If you intend to verify flow with an external device, careful attention should be paid to the combined tolerance of both the valve and the measuring station. For example, if both devices have a stated tolerance of +/- 10%, a reading of anywhere between 80% and 120% of design should be considered acceptable.

There are several PI valves on the market that attempt to report a theoretical or calculated flow based on the valve position. This is often based on the assumption that the delta P over the valve is within the required range, and that sufficient flow is available. Unfortunately, mechanical PI valves do not report delta P or the diaphragm position. For that reason, it is not advisable to calculate flow based on the position of the valve alone, as an isolated valve would still be reporting its theoretical flow.

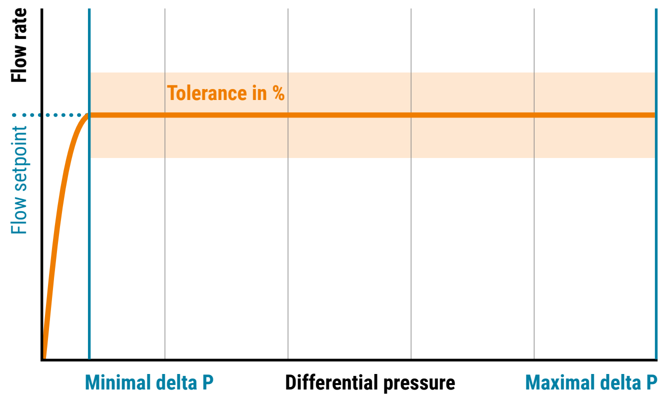


Figure 11: Improved stability with mechanical PI valves

2.4 Electronic PI valves

For almost a decade, Belimo electronic PI valves have had fast growth as more and more customers enjoy the peace of mind that they get with this innovative product.

What are the components of an ePIV?
An electronic PI valve, often referred to as an ePIV, combines a flow meter with patented glycol compensation, a high resolution actuator and flow control logic into one device. Flow measurement data from the meter can be collected via analogue interfaces or digital communication through Belimo MP-Bus, and optionally BACnet or Modbus. This provides valuable data to your building management system and allows a previously unavailable level of insight into your hydronic system.

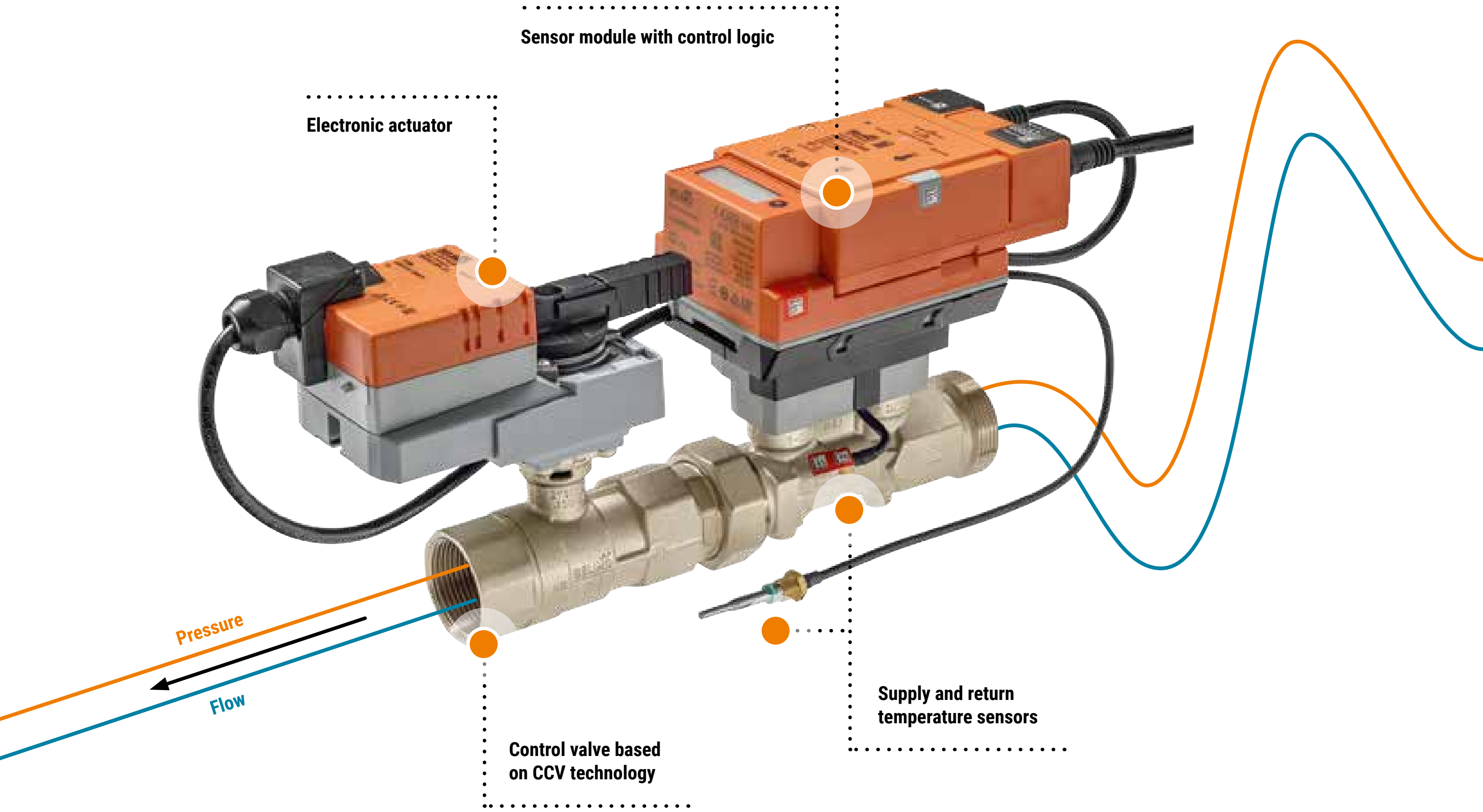


Figure 12: Belimo electronic PI valve, eg. an ePIV

How does the ePIV work?

The electronic Pressure Independent Valve (ePIV) uses technology very similar to the universally accepted pressure independent VAV box used in air-side applications. By using algorithms incorporated into the smart valve, the control signal DDC is interpreted into a flow requirement, which the valve positions to provide, delivering distortion-free characterised flow.

Positioning logic within the electronic valve is key to controlling pressure and flow accurately. The valve positions itself to be within 1% of the required flow, and will remain at that position until the flow value is outside its internal control tolerance of 5%. This prevents continuous movement of the actuator, as minor pressure variations are typically removed by the system before the valve must correct its flow by changing position.

Like mechanical PI valves, electronic PI valves also require differential pressure within a certain range to work. Electronic PI valves are able to maintain pressure independence at significantly lower differential pressures, as the ultrasonic flow measurement remains accurate down to very low flow rates, and they do not require pressure to work a regulator.

Pro Tip

Although electronic PI valves can maintain flow when the differential pressure drops below the minimum requirement for PI, any pressure change will result in large flow rates, accentuating valve moments to correct flow deviations.

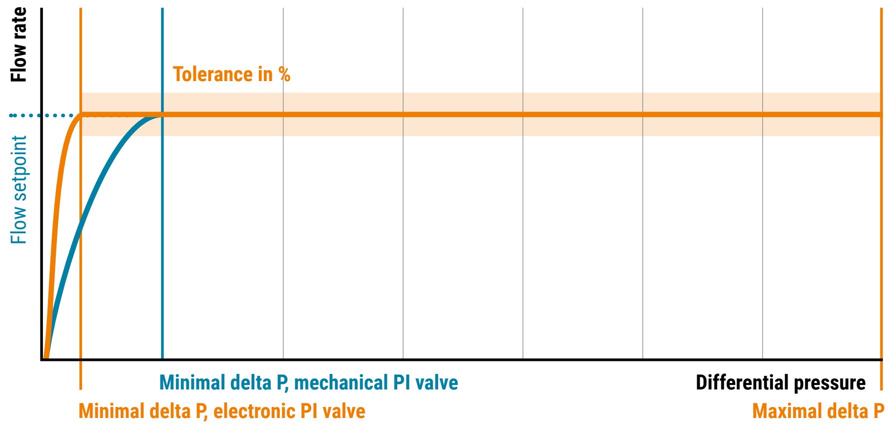


Figure 13: Electronic PI valves can maintain flow at lower delta P than mechanical PI valves

2.5 What advantages do electronic PI valves offer over mechanical PI valves?

Commissioning

Continuous true flow measurement has removed all the flow verification frustrations associated with mechanical PI valves, either from an assumed flow using valve position or trying to read flow from an external device. By reporting the true flow rates to the building management system of choice, you have not only removed any working from height that is typically associated with waterside commissioning terminal units, but you have also made continuous commissioning feasible.

Operation transparency

Product longevity and reliability should go hand in hand. Control valves, once commissioned, are not often revisited in a building's lifetime to ensure their optimum operation. Both pressure dependent and mechanical PI valves can, and often will deviate from design. This can be either due to the difficulty in adjusting the flow during commissioning, or due to not knowing whether the regulator is working correctly in the case of mechanical PI valves. An electronic valve will always report its flow, ensuring your piece of mind over the lifetime of the device. Common issues such as isolated or bypassed units, and even backwards installation of the valve, can be spotted easily and dealt with before it becomes a bigger issue. A failed valve will become obvious to an operator and can be alarmed on the **BMS**, or become an alert on your analytics software.

Improved dirt performance

Thanks to their simplified water path, electronic valves excel in environments where dirt is present. The smallest Belimo electronic valve will pass a 6 mm particle, and even if the valve is controlling at high delta P, the particle causing a blockage is reported as a lack of flow, which will make the valve simply drive open until the particle causing the obstruction passes through the valve. This effectively eliminates the need for terminal strainers and the additional pressure drop they create.

Figure 14: Electronic PI valves have a simple flow path, removing flow direction changes and significantly improving dirt tolerance

Pro Tip

In every closed circuit, a **central** method of removing dirt and air is considered best practice. Using Belimo electronic valves means this is the only form of dirt removal required. Additional terminal unit strainers are not required.

2.6 Harmonise the pump speed based on electronic PI valves position

Critical Zone Reset (CZR)

Hydronic variable flow systems may reset supply water temperature, pump static pressure, or a combination of both in order to reduce plant energy consumption, and to comply with building codes and standards. The information on the chart in figure 15 illustrates one of the ways in which valve position feedback to the **building automation system (BAS)** may be used to reset the pump pressure setpoint. In this example, in accordance with **ASHRAE 90.1**, the index valve position is used to reset the pump pressure setpoint.

The term 'Critical Zone Reset' is used to describe the BMS's automated demand response logic as illustrated in the chart. Under normal operation, the speed of the pump is controlled by the position of the control valve's actuators. One of the valves need to be almost 100% open to satisfy the load – this is the critical zone. When the critical zone valve starts to close-off, that is a sign that the pump speed can be reduced until the valve is almost fully open again. This logic enables a highly energy-efficient operation of a hydronic circuit.

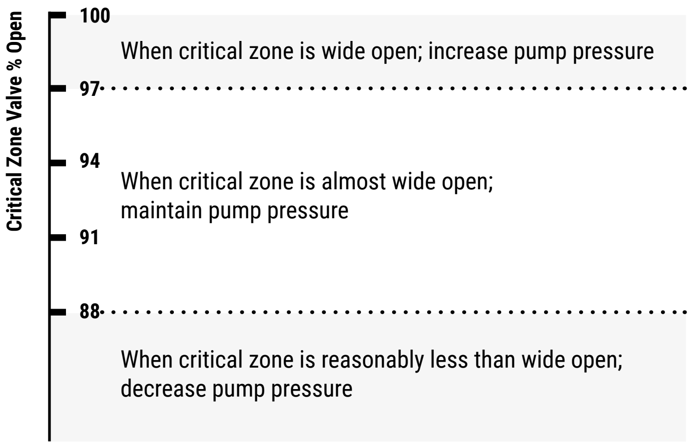


Figure 15: An example Critical Zone Reset (CZR) strategy

Pro Tip

Using the data provided from Energy Valves, you can optimise this process. Section 5.7 of this guide explains more.

Mechanical versus electronic PI – impact based on pump pressure
The Belimo ePIV and the EV position information allows pump pressure reset that automatically optimises pump pressure according to CZR, by increasing or decreasing pump speed, or its pressure setpoint. In response, the critical zone's ePIV or Belimo Energy Valve™ actuator will close the valve to suit the increased pressure, while maintaining the required flow. In contrast, a pressure dependent valve would remain fully open, in effect delivering an overflow to the coil. A mechanical PI valve would also remain fully open, however, an internal diaphragm would move to restrict the flow to design. These unseen diaphragm changes make mechanical PI valve positions not suitable for use with CZR.

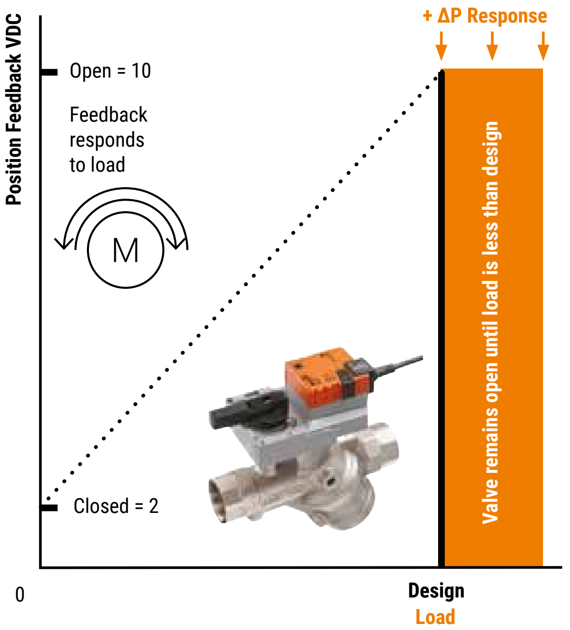


Figure 16: Pressure dependent and mechanical PICV

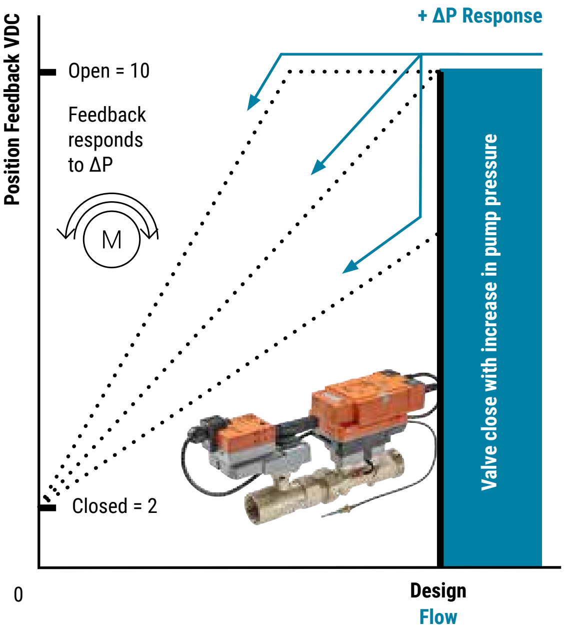


Figure 17: ePIV or Energy Valve

Pro Tip

When planning a Critical Zone Reset system, you will need a BMS network that is able to quickly communicate with the installed valves, analyse that data and make control decisions.

More accurate flow measurement

The **wet calibrated** ultrasonic flow meter, which is an integral part of all ePIVs and EVs, measures more accurately than a typical venturi or orifice plate. It is able to provide true flow information through **transit time technology** instead of flow calculations, using differential pressure and flow coefficients. Continuous flow rate feedback, available from the valve, allows flow measurements to be displayed or trended by the BMS.

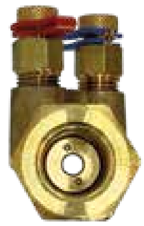


Figure 18: Mechanical measuring station

Are there any challenges with electronic PI?

Due to the method electronic PI valves use to achieve pressure independence, they theoretically take more time to react to large system pressure changes than mechanical PI valves. Thankfully, large and fast pressure changes are rare, as variable speed drives and advanced pump control systems will prevent such sharp pressure changes from happening. Figure 20 shows how electronic valves react to significant pressure changes. The top graph shows the actual flow with the control dead-band overlaid; as pressure increases, the flow moves outside the dead-band, and the valve reacts as shown on the bottom graph. Later, the pressure reduces, causing the flow to move outside the control dead-band again, resulting in another valve position correction, as shown on the bottom graph.

Figure 19: Wet calibrated ultrasonic flow meter, part of the Belimo Energy Valve™

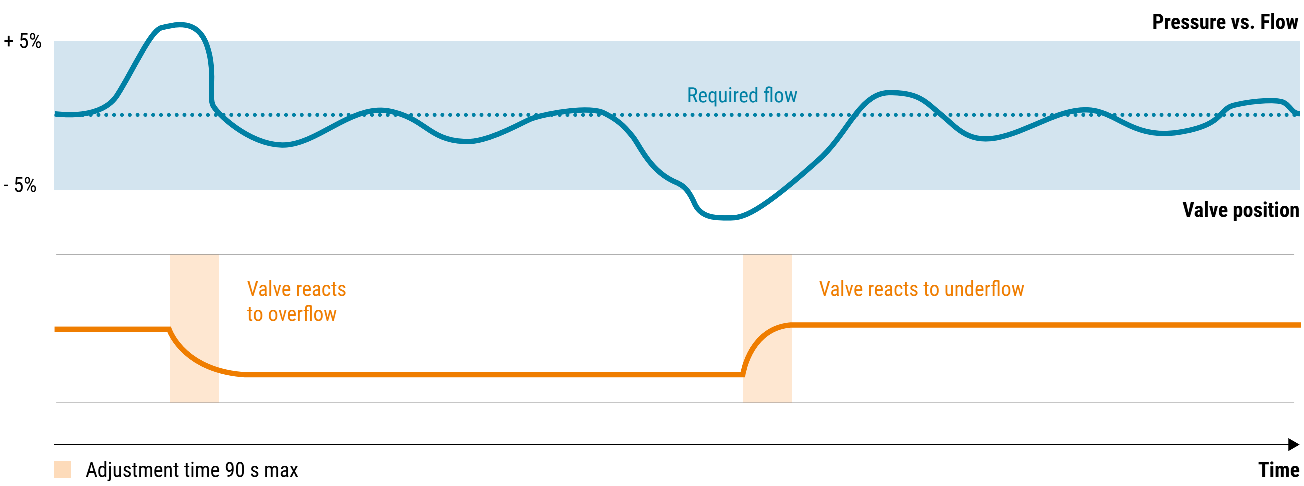


Figure 20: Reaction of ePIV to pressure changes

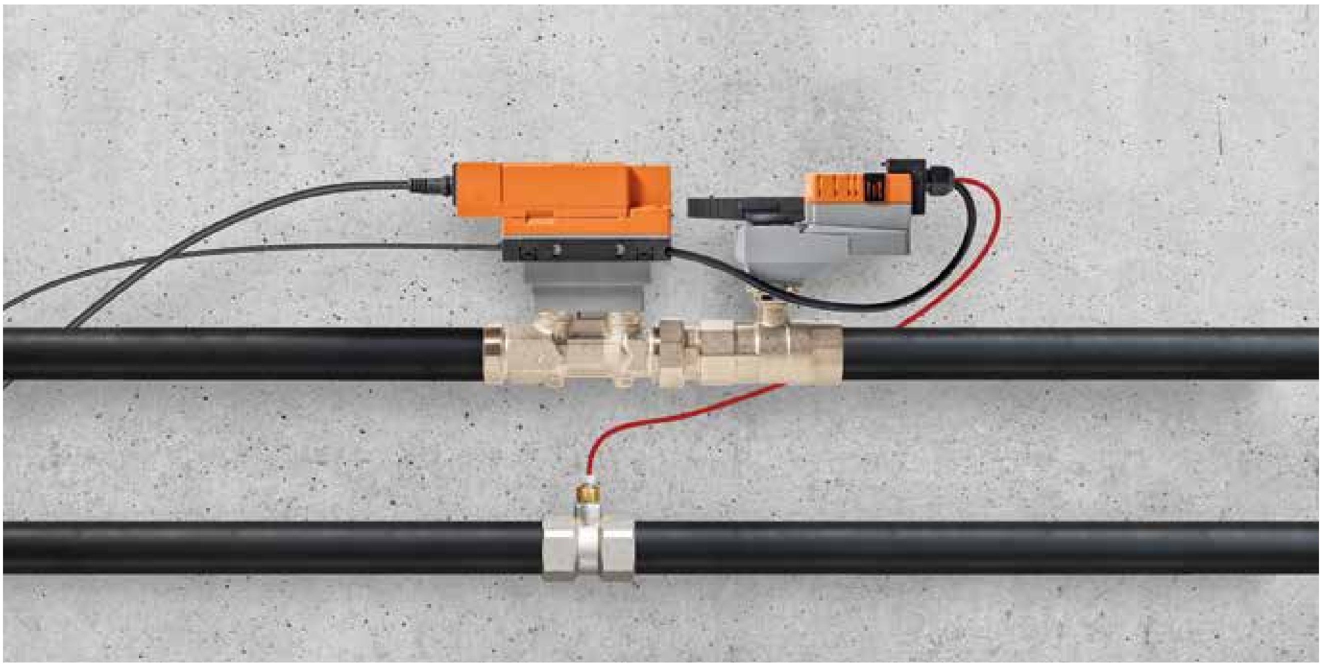
3

What is a Belimo Energy Valve™?

3.1 Main features

The **Belimo Energy Valve™ (EV)** is a smart pressure independent control valve for HVAC applications. It is based on the Belimo **Characterized Control Valve (CCV)** technology that has an 'air bubble tight' close-off, delivering zero leakage. The flow through the valve is permanently measured with an ultrasonic flow sensor. The sensor is accurate, and it can include a patented method of detecting and compensating for glycol. The accurate flow information is used to electronically **compensate for any pressure fluctuation** in the system. Combined with the temperature sensors in the supply and return pipe, it is also used to **measure the energy** supplied to a coil.

The EV has a patented, built-in **Power Control** and Belimo **Delta T Manager™** logic to monitor coil performance and to optimise the heat exchange taking place, by maintaining delta T. In addition to the standard analogue signal and feedback wiring, the EV communicates its data to the building management system (BMS) via Belimo MP-Bus, BACnet or Modbus communication. The built-in web server makes the EV easy to configure and enables clear visualisation of the valves' operation in real time. Performance data is stored for 13 months on the actuator. The Belimo Cloud provides the option of lifetime data.



Overview of the main features of the EV

IoT-ready		
Measures Energy	Controls Power	Manages delta T
Compensates Pressure Electronically		
Includes Strengths of a CCV		

Figure 21: Main features of the EV solution

3.2 Energy valve pillars

CCV strengths

Characterized Control Valve (CCV) accurately reproduces the equal percentage curve, allowing enhanced control at low flows. he CCV is also 'air bubble tight', meaning it does not permit any water to pass or leak through the valve when closed. The CCV continues to be the best-selling control valve on the market with millions sold worldwide.

Compensates pressure electronically

Using a flow meter and advanced high resolution actuator, the Energy Valve positions to provide the required flow using feedback from a flow meter without a traditional PI cartridge. Energy Valves sense pressure changes as changes in flow. They react to large pressure changes by moving the valve until the correct flow is achieved, remaining there until either another large pressure change is experienced, or the required flow is changed.

Measure energy

Flow through the valve is continuously measured using a wet calibrated ultrasonic flow meter. When combined with a matched pair of temperature sensors, the valve measures the energy consumed by the heat exchange device.

Control power

Not only can the valve measure energy, it can also control it. Power control is a complete departure from traditional flow characteristics. The control signal DDC is interpreted into a power requirement, and this makes the valve control independent of pressure, water temperatures and air volumes.

Manage delta T

Delta T is an excellent indicator of heat exchange efficiency. The Energy Valve includes two options for managing delta T, one designed for fixed flow temperatures, and the other for facilities that vary flow temperatures.

Digital-ready

In addition to the standard analogue signal and feedback wiring, the EV can communicate its data to the building management system (BMS) via Belimo MP-Bus, BACnet or Modbus communication. The built-in web server makes the EV easy to configure and enables clear visualisation of the valves' operation in real-time. Performance data is stored for 13 months on the actuator. The Belimo Cloud provides the option of lifetime data.

3.3 Delta T, and why it's important

Efficiency gains and pump savings

While the formula for heat exchange is exact, the reality of the buildings' operation is far from exact. Our quest for comfort has made modulating control valves and varying air flows a reality. However, this turns optimum heat exchange into a moving target, as ideal air volume and water flow rates are interdependent and non-linear.

The temperature spread between water entering and leaving a heat exchanger is what is commonly referred to as its delta T. This is a measure of how much energy the water has given up as it passed through the heat exchanger. If this is lower than expected, less energy is being given up. This is concerning as a significant amount of energy is put into the water, and a further amount of energy expended moving that water around the building.

A key concept of low delta T is the heat exchanger is receiving too much water. The Energy Valve eliminates these overflows by slowing the water down until the heat exchanger gives up the desired amount of energy. This is a crucial feature of the Energy Valve.

Reducing flow rates to optimise heat exchange has a significant effect at the pumps and the plant. This is why many district energy providers have surcharges for operators returning low delta T.

Figure 22 shows the pump affinity law, which shows us that the relationship between pump power consumption and flow is cubed. A 30% reduction in flow is around a 50% energy consumption.

$$\frac{P2}{P1} = \left(\frac{V2}{V1}\right)^3$$

Figure 22: Pump affinity law

Low delta T isn't all about pump savings either. The central plant is compromised when the consumers do not maintain delta T.

Central plants suffering from low delta T typically lack capacity during peak times as the water flows too quickly to impart sufficient energy.

3.4 Components of the Belimo Energy Valve™

Electronic actuator accurately positions the valve based on the flow requirement

2-way characterised control valve with tight close-off and 0% leakage

Ultrasonic flow meter with temperature and glycol compensation

Supply and return temperature sensors to **capture delta T**

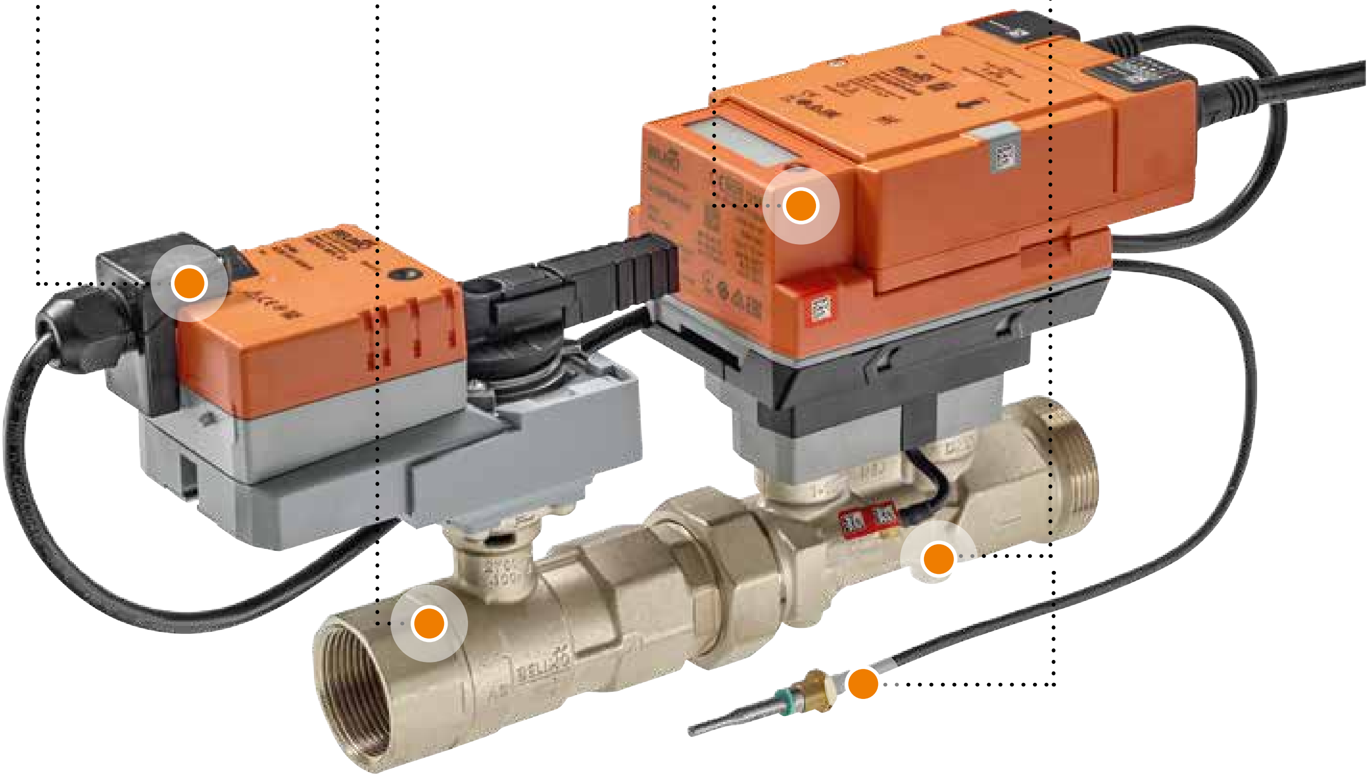


Figure 23: Components of the EV

3.5 EV product range and key specifications

Belimo Energy Valve™											
Nominal diameter [mm]	15	20	25	32	40	50	65	80	100	125	150
Nominal diameter [in]	1/2	3/4	1	11/4	11/2	2	21/2	3	4	5	6
V'nom [l/min]	21	39	69	108	150	288	480	660	1200	1860	2700
V'nom [GPM]	5.5	10.3	18.2	28.5	39.6	100	127	180	317	495	713
Adjustable design flow rate % of V'nom	30 - 100										

Figure 24: Overview of the available range of EVs

3.6 Belimo Energy Valve™ features

Energy Monitoring

Permanently measures and logs the energy usage of the application, the flow and the differential temperature across the coil. This creates full load transparency in the system.

Characterised Control Valve Technology

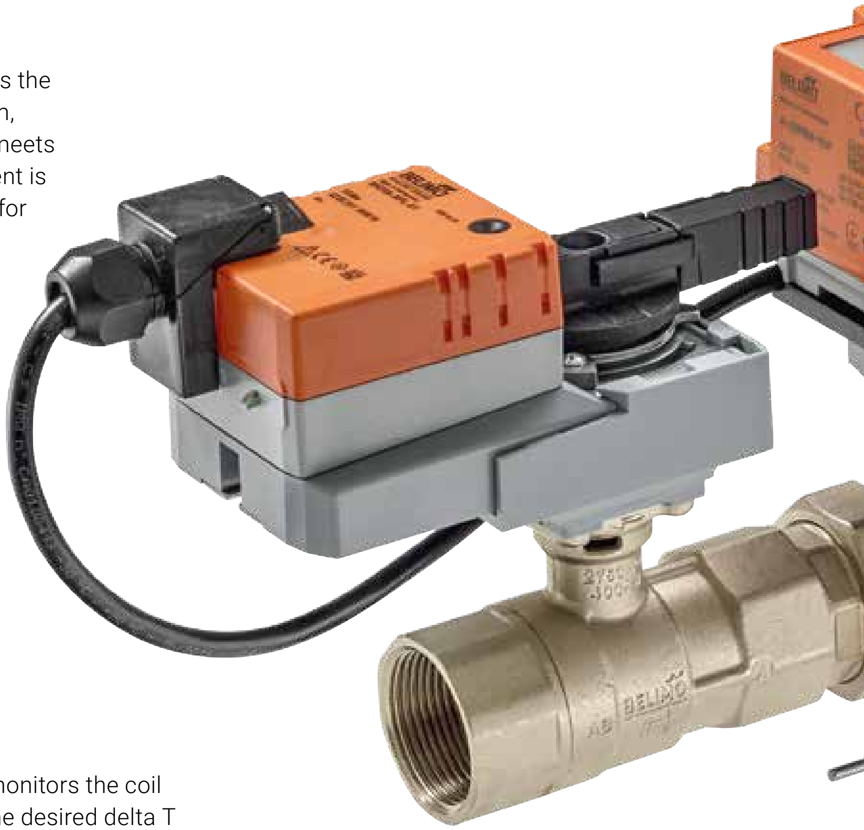
Improves light load control, provides self-cleaning, and assures higher close-off and zero leakage.

7-Year Warranty

When the EV is permanently connected to the cloud, the warranty period is automatically extended by two years, to seven years total.

Glycol Monitoring

An advanced, patented algorithm monitors the percentage of glycol content in the system, helping to ensure that the concentration meets design needs, and the energy measurement is compensated accordingly. Only available for non-MID certified products.



Power Control

Power control rewrites the rules on control flow characteristics. This dynamic mode provides the only truly linear relationship between control signal DDC and power output. This control mode makes the EV both pressure and flow temperature independent, delivering comfort and minimising control oscillations, all while increasing system efficiency.

Delta T Manager

This function continuously monitors the coil delta T and compares it to the desired delta T setpoint. If the actual delta T falls below the setpoint for a pre-determined period, the mode goes active and adjusts the flow until the delta T is at or above the set minimum.

Low Minimum Pressure Drop

Electronic PI valves have a much lower pressure drop that mechanical PI valves, and therefore require significantly lower differential pressures to achieve designed flow. This enables smaller pump dimensions and energy savings.

Bus Communication/NFC

NFC enables the ability to read current values, write settings or configurations through handheld tools, BACnet IP/MS-TP, Modbus RTU/TCP-IP, Belimo MP-Bus networks, and a built-in web server.

Simplified Troubleshooting

The on-board web server provides statuses for connected temperature sensors, flow meter and actuator performance. It will even tell you if there is too much air in the water. The EV is also a useful tool for total system troubleshooting, providing information on pressure, flow temperatures, etc.

Embedded Web Server

The embedded web server delivers a single, easy-to-understand point of access, which details the status of the valve, alarms and warnings. This makes setup, commissioning and troubleshooting the EV easy by non-technical personnel.

Delta T Optimisation and Flow Setpoints

Optional cloud analysis provides recommended delta T, flow and power setpoints that can be updated remotely or automatically to further improve energy efficiency. Web server data can be downloaded and entered to the Savings Estimator Tool for detailed analysis.

Performance Reporting

Key performance indicators are available on the web server and via field bus, they detail current and historical performance data. When connected to the cloud, a detailed report containing year over year thermal energy data is generated quarterly and is optionally sent out via e-mail.

KPI Data

Important data such as delta T, flow, valve position, heat transfer and thermal power can be stored securely for up to 13 months on the device, and for its lifetime when connected to the Belimo Cloud.

Startup Assistant

The Belimo Assistant App offers simple configuration, fast commissioning and programming options.

IoT Readiness

By 'opting in' on the web server, and opening a outgoing port on your firewall, your EVs can securely connect to the Belimo Cloud. Doing so offers a wealth of benefits, including product updates, online technical support, archiving of data, and the capability to use our expertise to check your current settings are optimal.

3.7 User benefits with Belimo Energy Valve™

Investor/End User

- Increase the energy efficiency of your building, reduce operating costs, increase the capital value of the building, and attract better rental yields.
- Ensure consistent comfort and the availability of peak energy performance of your plant all year round.
- Ensure circuits are correctly and continually balanced, while tenant improvements or occupancy changes do not affect the comfort of others.
- Reduce pumping and chiller/ boiler operating costs by increasing plant efficiency and eliminating waste zone operations.
- Make informed decisions about plant upgrades or replacement using historical data stored on the energy valve or on the cloud.
- Get the most out of your current plant. Eliminating low delta T syndrome will ensure reported capacity issues are not a result of overflowing coils, or ghost energy.
- Showcase your building by utilising state-of-the-art technology.

Planner/Consulting Engineer

- Provide your clients with an industry-leading product, proven to save energy and provide valuable insight into the operation of the building.
- Offer continuous commissioning, with minimum cost.
- Perform remote flow verification, by allowing 100% of the Belimo Energy Valves™ installed in a building to be witnessed in the time it would traditionally take to examine one.
- Assure a dynamically balanced system under all operating conditions.
- Simplify troubleshooting with 13 months of stored data and an easy-to-use excel tool to interrogate that data.
- Ensure full system capability at peak times, and identify savings for the rest of the year by eliminating low delta T syndrome.
- Remove the 10% typically allowed for commissioning tolerances, and reduce pipe work and unnecessary pump head.
- Provide your clients with a product that has an industry-leading warranty, with service and support available around the globe.

Installer/Mechanical Contractor

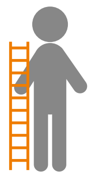
- Save material and labour cost with the all-in-one EV, integrating the control valve, balancing valve, actuator and energy meter.
- Remove device level strainers. The energy valve is one of the most dirt tolerant valves on the market.
- Reduce your waterside commissioning time by using a valve that measures water flows for you.
- Reduce the risk of late handover, by making use of the possibility to verify piping configurations and flow rates earlier in the project, using simple tools.
- Solve problems and simplify troubleshooting with on-board diagnostic tools.
- Provide your clients with a reliable product with an industry-leading warranty for complete piece of mind.
- Simplify glycol dosing by using the embedded glycol monitoring of the EV. This removes the risk of over dosing, saves chemical costs, and allows peak pump performance and efficiency to be maintained.
- Have Belimo's support engineers always at hand by bringing your EV online. Remote support to help maintain the product throughout its life is just a few clicks away.
- Increase site safety, minimising working at height during commissioning and witnessed handover.

System Integrators/Control Contractors

- Provide transparent systems, allowing complete visualisation of energy consumption, all from a single, easy-to-integrate device.
- Solve your client's low delta T problems, reduce their pump operating cost, and release plant capacity, all while maintaining comfort levels.
- Reduce installation time and complexity by combining several devices into one. Both control and mechanical setup is easy with the assistant wizard.
- Easily investigate and troubleshoot local issues with on-board diagnostics, and system wide hydronic issues using the data held on the EV.
- Monitor glycol levels and report them on BMS. It's even possible to auto dose glycol using the EV.
- Identify design water flow rates and correctly setup the plant, even when design information is not available.
- The Energy Valve delivers ideal information for your cloud analytics platform to make better client recommendations, increasing savings and the value of the offering to your client.
- Use power control to easily manage any load shedding requirements, reducing power equally among all the EVs or just to select units.

Energy Service Company

- Provide a reliable and proven way to save substantial energy in an HVAC system, with a relatively low initial investment.
- Save your customer utility/ energy cost and penalties from low delta T values below the agreed level.
- Make use of the recommended delta T and flow setpoints via cloud connection, to save time and to improve efficiency.
- Provide advanced solutions for clients incorporating cloud-based analytics, to benchmark and optimise system performance.
- Get graphically illustrated performance reports from each EV, showing current and historical data of flow rates, energy usage, delta T, and other points of interest.



Facility Manager

- Areas with no flow or insufficient pressures are easily identified before occupant comfort is compromised.
- Make use of the data available on the Belimo Energy Valve™, so complex and often transient problems can be identified, diagnosed and rectified.
- Monitor glycol content to enable you to maintain the correct glycol concentration, increasing overall heat transfer and pump efficiency.
- Reduce pump and chiller/boiler operating costs by increasing plant efficiency and eliminating heat transfer operation in waste zones.
- Provide reliable operation and occupant comfort.
- Enable real time technical support via remote service technology.
- Ensure coils are dynamically balanced to offer true flow control.
- Easily troubleshoot problem areas using the embedded web server to find valve, plant or even control issues using the 13 months worth of data installed.
- Quickly and easily verify the buildings capability to perform, using the true flow rate feedback from the Energy Valves™, either directly or via the BMS.

4

Control Modes of the Belimo Energy Valve™

The Belimo Energy Valve™ offers various modes of controllability. These can be set during commissioning and changed at any point through the settings function of the valve.

4.1 Position control

In this mode, the Belimo Energy Valve™ actuator positions solely on the control signal DDC input. This should only be used in very specific situations:

a) during evaluation periods where a base line flow needs to be established;

b) for finding the saturation point of the heat exchanger(s) that the valve serves;

c) to establish flow over a period of time, to evaluate energy savings achievable when flow control is enabled.

Why use this?
For benchmarking when you wish to establish the savings the Belimo EV is going to provide. For example, as part of the commissioning process, you can compare the energy consumption of the system in the position control mode to the consumption in the power control mode.

What is required at the valve?
The Belimo EV will arrive from the factory in flow control mode. To enable position control, a change in the settings is required. Position control is not pressure independent, and should be used for short periods of time only.

Figure 25 shows an equal percentage characteristic (blue line), and the other lines above it represent control distortions likely to occur if the valve is left in position control. Energy Valves are physically characterised with an equal percentage curve. However, in position control mode, the valve is not pressure independent, and is very likely to suffer from authority issues as represented in this chart.

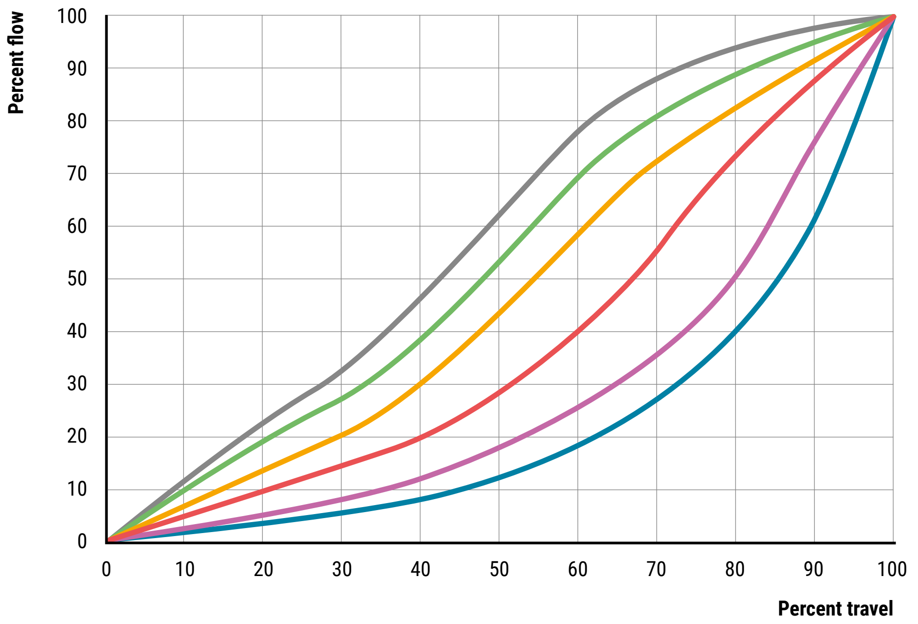


Figure 25: The distortion of the characteristic that could occur if the valve is left in position control

4.2 Flow control

The Belimo Energy Valve™ interprets the control signal DDC as a flow rate setpoint. The valve modulates to maintain the required flow, making the physical position of the valve dependent on flow and current pressure conditions. The desired flow will be maintained automatically and reported digitally as a point, and is the default analogue output.

Flow control is a control algorithm that creates a defined relationship between the control signal DDC and the flow output. The EV interprets the control signal DDC as 0 to 100% of the specified flow through the Energy Valve™. The Valve control is pressure independent in flow control mode.

What is required at the valve?
Design Flow Rate – This will be the maximum flow allowed by the valve, also referred to as **V'max**. This value should match the design flow value of the coil.

Figure 26 shows the characterisations typically available for PI valves, and the relationship between flow and control signal DDC. Figure 27 shows the control characteristic, and how the valve maintains the correct flow within tolerance over the entire range of pressures.

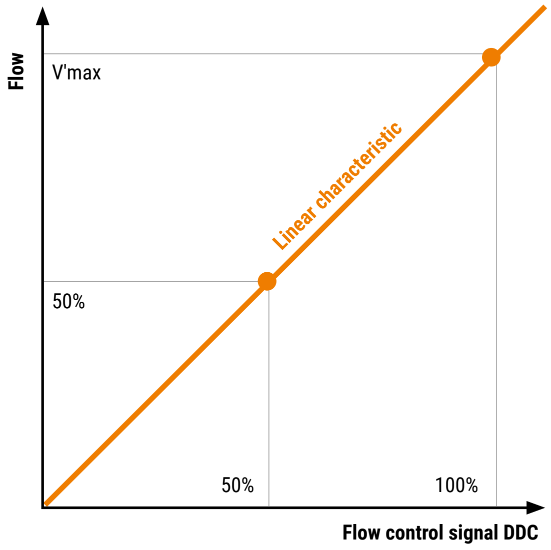


Figure 26: Flow characteristics related to flow control signal DDC

Pro Tip

V'nom is the maximum flow through the valve, and V'max is design setting. When selecting any PI valve, try not to select a valve where your design is very close to V'nom.

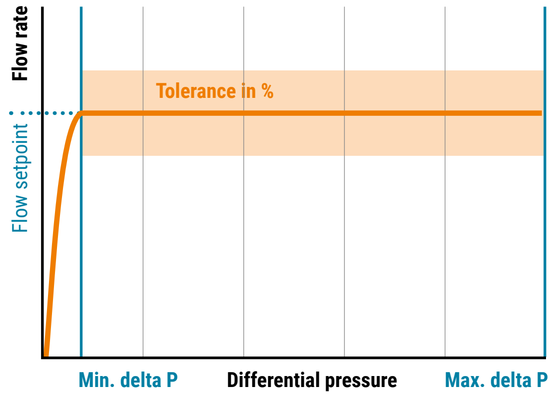


Figure 27: Control characteristics in flow control mode

4.3 Power control

Power control is a control algorithm that creates a linear relationship between control signal DDC and power output. The Belimo Energy Valve™ interprets the control signal DDC into 0-100% of the specified power output to the consumer. Power control outperforms equal percentage, as the function is not affected by air volumes, water temperature changes, or the subtle differences between coil characteristics. Power control is the only method of delivering a true linear relationship between control signal DDC and output.

This feature uniquely allows variable flow temperatures in buildings that would not normally be able to utilise this function. For example, in a cooling application, if there is one space that requires very precise control, normally when water supply temperature increases, there is a time delay until the local DDC zone controller reacts. Whereas, with power control enabled, the EV reacts to increase in flow temperature much faster than the DDC can, therefore maintaining the demanded power and if enabled, preventing low delta T with Delta T Manager.

Using power control is a great way to manage any load shedding requirements. You can reduce power equally, or select units to deliver the required savings.

Why use this?
Being both temperature and pressure independent, power control offers a control stability not previously seen from a control valve. Power control ensures a given control input. Heat exchanger power output remains constant despite changes in the variables on which the heat exchange formula is based. Ideally you should use it everywhere, however, it is particularly useful for temperature or performance critical applications where a variable supply water temperature would otherwise not be suitable.

What is required at the valve?
The following information needs to be considered:

Design Flow Rate (V'max) – This will be the maximum flow the valve will allow. Maximum flow limiting is still active in power control mode.

Design Maximum Power (P'max) – This will be the maximum power the valve will allow.

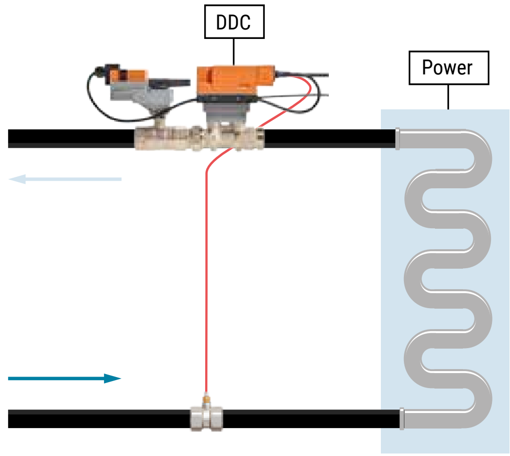


Figure 28: Power control of the energy input to a consumer

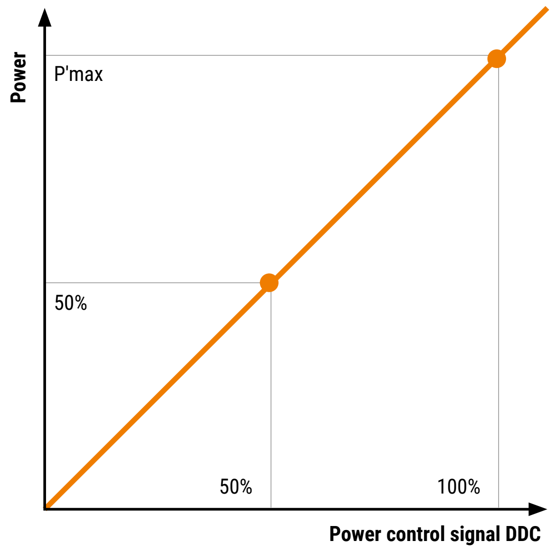
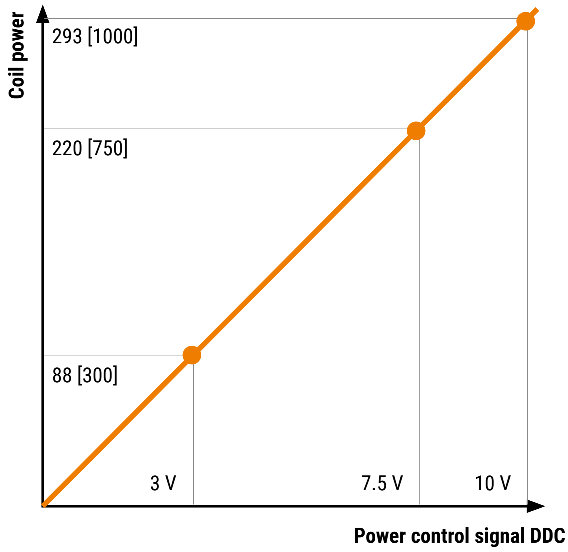


Figure 29: Control characteristics in power control mode

Pro Tip

Use the digital settings within the EV's web interface to set power control and adjust or limit the power of the coil. Use the analogue input signal to vary the power within the minimum and maximum of the control signal DDC. Uniquely, when required, you are able to reduce the maximum power output from the coil. This is great for load shedding, or if the peak load exceeds the capability of the plant, you can equally limit the power or favour certain areas.

Example of a coil using power control
Figure 30 shows an example of an 293 kW [83 tons] AHU to be controlled. Here it is easy to understand the linearity of power control. When you require 293 kW or [83 tons], it is your 100% of coil power, which means it requires 10 V or 100% of control signal DDC. If the capacity required now changes to 30%, this means 88 kW [25 tons] or [300 kBTU/h], and the control signal DDC needed is 3 V.



Example: AHU power

83 tons ~ 293 kW ~ [1000 kBTU/h] coil

3 VDC = 88 kW ~ [300 kBTU/h] output

7.5 VDC = 220 kW ~ [750 kBTU/h] output

10 VDC = 293 kW ~ [1000 kBTU/h] output (P'max)

Figure 30: Example of a coil using power control mode

4.4 Delta T Manager

The Delta T Manager monitors the delta T across the coil. When the delta T drops below the setpoint, the Delta T Manager logic throttles the valve position for lower flow, to increase delta T closer to the setpoint. The EV therefore offers a simple-to-understand method of reducing flows when the water is passing too quickly, to allow optimum heat transfer.

Why use this?
This mode will reduce your heat exchanger overflows in situations where the delta T of a heat exchanger falls below the required standard. Delta T Manager is best used for fixed flow temperatures. If you vary your water temperature, you should consider using delta T scaling (see chapter 4.5).

What is required at the valve?

The following information needs to be considered:

V'max – The design flow of the heat exchange device.

Delta T Limiting Value – This is the ideal temperature difference between flow and return.

Example of fixed delta T setpoint operation
The charts shown on figures 31-33 explain the function of the Delta T Manager on a valve that controls a cooling coil. The blue line represents the cooling demand, and the flow setpoint comes from the DDC. The green line is the measured delta T from the coils supply and return temperature. The black line is the desired delta T 7.7 °C [14 °F].

With the Delta T Manager active, the overflow situation with delta T below the setpoint is recognised, and the Delta T Manager takes control. Now, the Delta T Manager restricts the flow of the valve to keep the delta T from dropping below the setpoint, as shown by the solid red and green lines.

What does low delta T do at the central plant?
Any overflow is delivered by the pumps. The relationship between flow and power consumption is cubed, so a small flow saving equates to a big power saving.

Central plant also benefits from the increased delta T. Part of the formula to calculate power output is based on delta T. A compromised delta T limits the maximum output from the central plant, often leading to lack of performance at peak times.

Actively managing your delta T by optimising heat exchange at each coil, is the best way to minimise waste.

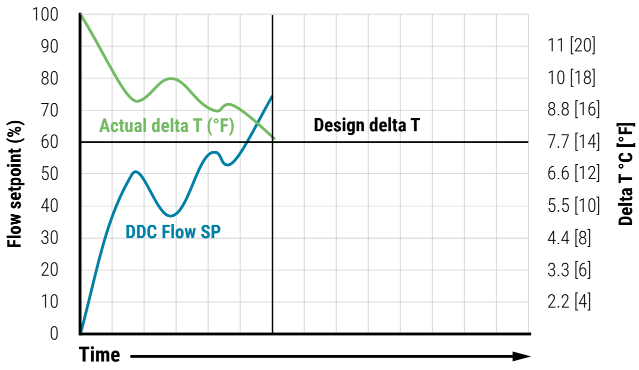


Figure 31: As the demand starts to rise and the flow changes, the actual delta T starts to decrease

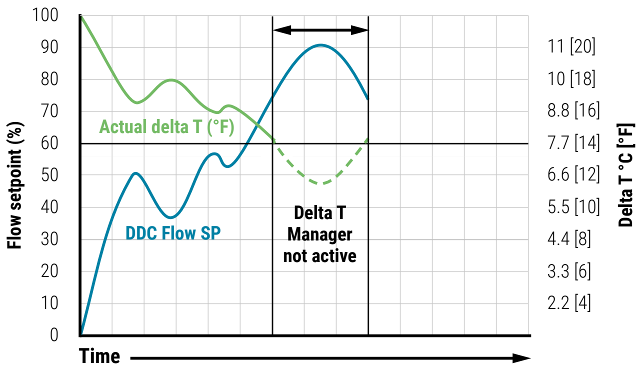


Figure 32: If the Delta T Manager was not active, the DDC setpoint drives the demand so high that the delta T will drop below the desired setpoint of 14 °F

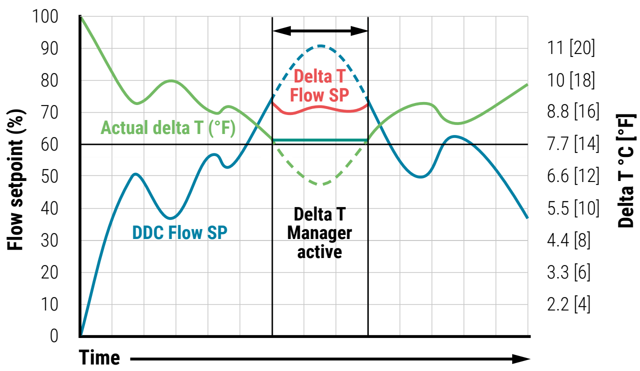


Figure 33: Delta T Manager detects low delta T, goes active, and manages the flow to maintain the minimum delta T

Pro Tip

The Energy Valve will only throttle flow down to 30% of design flow. During periods of low delta T, you can set a specific minimum using the web browser or Assistant App.

Case Study

The effect of the Delta T Manager

A case study at the HVAC facility of a global technology company was conducted, to determine the effects of the various EV control modes on the heat exchange process in an air handling unit (AHU) and their effect on energy consumption.

With a given power requirement to generate 60 tons of cooling load at the AHU, the settings of the EV were varied as follows:

1. **Position Control** – Functions as a pressure dependent ball valve. On average, 240 GPM to achieve 60 tons.
2. **Flow Control** – Functions as electronic pressure independent valve. On average, 144 GPM to achieve 60 tons.
3. **Flow Control with Delta T Manager** – Functions as an electronic pressure independent valve with delta T limiting set at 15 °F. On average, 96 GPM to achieve the same load of 60 tons.

The graphic depicts all the operating points (delta T and thermal load) of the control valve in the three different control modes. After testing and collecting all the data for the generation of 60 tons of cooling load, the results were as follow.

The conclusion of this study was as follows:

By examining the graph, it can be seen that when the Delta T Manager was enabled, the Belimo Energy Valve™ used roughly 2.5 times less water to achieve 60 tons of cooling capacity than when it was mimicking a conventional control valve. Delta T also increased from approximately 6 °F, in conventional control mode, to 15 °F using the Delta T Manager. Optimising the performance of the AHU with no loss of occupant comfort is what is achievable with the EV.

A 3rd party company was in charge of analysing the data collected during the pilot programme. Although use of the Belimo Energy Valve™ has yielded tremendous energy and cost savings of potentially $1.5 million per annum, the real lesson of this particular test was how the valve could be used as a preventive maintenance tool, and its importance in creating long-term sustainability.

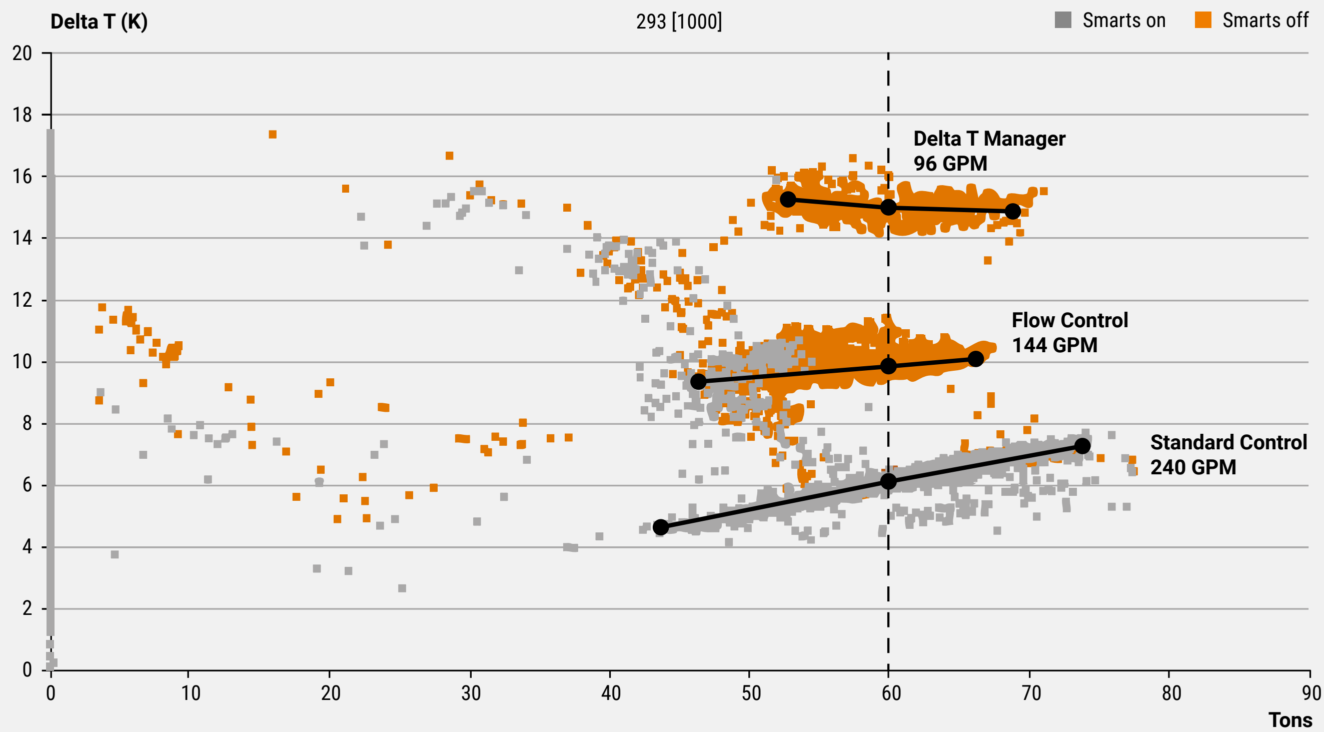


Figure 34: Operating conditions (delta T and load) of the valve in different control modes

4.5 Delta T Manager scaling

The 'Scaling Delta T Manager' offers an alternative to the fixed delta T setpoint management mode, which was explained in section 4.4.

This function allows the variation of the delta T value. The valve will allow lower waterside delta T at lower flows, enforcing stricter delta T as you get closer to design. The controlled delta T is no longer a single set value, but a band of possible delta T values, as shown in figure 35.

This band of delta T values demonstrates the concept of scaling delta T. The flow at which saturation is reached depends largely on the operating state of the coil. If the inlet temperature is changing often, simply limiting the flow does not optimise the coil behaviour.

Why use this?
The higher the supply temperature (in cooling applications), the less energy the chiller has to put into the water. This offers significant energy savings from the chiller. However, higher supply temperatures are closer to the entering air temperature of the heat exchangers, so the maximum possible energy transfer is reduced, therefore reducing the maximum delta T achievable from the heat exchanger. Delta T scaling helps to find the balance between economy at the plant during periods of low load, and ensuring delta T is maintained when loads are higher.

What is required at the valve?
Delta T Flow Saturation Value – Assuming that you are unlikely to have saturation values, simply enter the designed flow.

Delta T Limiting Value – This is the ideal temperature difference between flow and return at design flow.

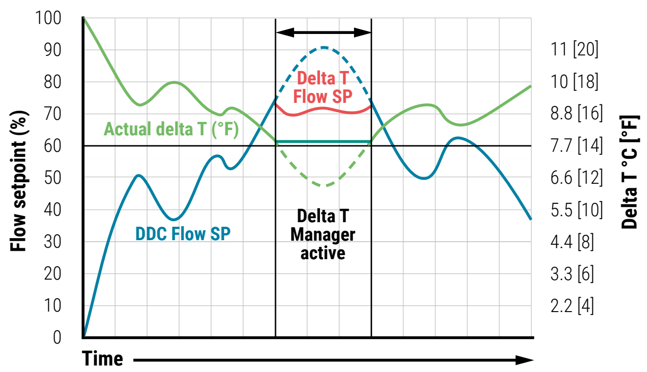


Figure 35: 'Scaling Delta T Manager' scales the delta T setpoint depending on the current flow rate

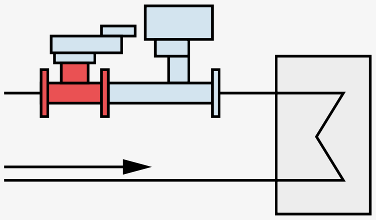
Pro Tip

If you would like to adjust flow temperatures based on demand with delta T scaling enabled, ensure you use the control signal DDC to establish demand as all other variables are misleading.

4.6 Control modes summary

Delta T Manager OFF

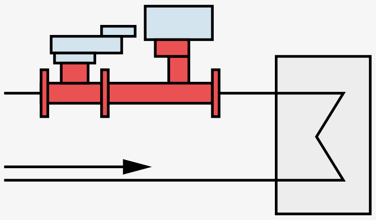
POSITION CONTROL



Y Signal controls the valve position

Position Control
The Energy Valve works as a normal pressure dependent valve. The actuator is positioned based on the control signal DDC. Use this only for troubleshooting or benchmarking purposes.

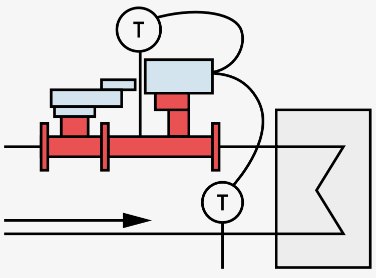
FLOW CONTROL



Y Signal controls the flow

Pressure Independent Flow Control
The Energy Valve works as an ePIV (Electronic Pressure Independent Valve). The valve reacts to any change in pressure and modulates the actuator, to maintain the flow setpoint based on the control signal DDC.

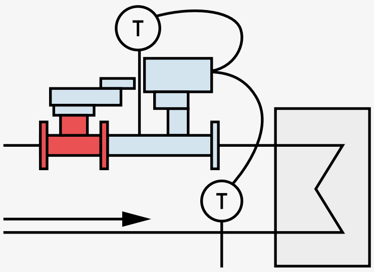
POWER CONTROL



Y Signal controls the coil thermal power setpoint (BTU/h or kW)

Power Control
The Energy Valve adjusts flow to maintain the thermal power setpoint. If the measured coil power is below setpoint, flow will be increased. If the measured coil power is above setpoint, flow will be decreased, as long as the defined V'max is not exceeded.

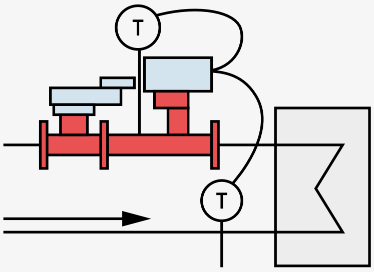
Delta T Manager ON



Y Signal controls the valve position, as long as the delta T is above the delta T setpoint

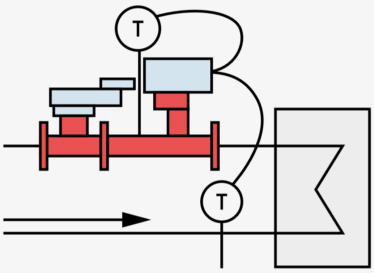
Position Control + Delta T Manager
The Energy Valve works as a pressure dependent valve. If the measured delta T is lower than the delta T setpoint, the flow will be reduced by the Delta T Manager logic to achieve the setpoint, regardless of the control signal DDC Y.

Note: In position control, only Delta T Manager can be selected. Delta T Manager scaling will not be available.



Y Signal controls the flow, as long as the delta T is above the delta T setpoint

Pressure Independent Flow Control + Delta T Manager
The Energy Valve works as an ePIV. However, if the measured delta T is lower than the delta T setpoint, the flow will be reduced by the Delta T Manager logic to achieve the delta T setpoint, regardless of the control signal DDC Y.



Y Signal controls the thermal power setpoint, as long as the delta T is above the delta T setpoint

Power Control + Delta T Manager
The Energy Valve adjusts flow to maintain the thermal power setpoint. If the measured coil power is below setpoint, flow will be increased. If the measured coil power is above setpoint, flow will be decreased, as long as the defined V'max is not exceeded. If the measured delta T is lower than the delta T setpoint, flow will be reduced by the Delta T Manager logic and this will override the thermal power control setpoint.

4.7 Belimo Energy Valve™ as an IoT device

While a Belimo Energy Valve™ can be easily integrated to a BMS, it is also ready to be connected to the internet. With the integration of the EV into the Belimo Cloud, users can create their own account and benefit from numerous free remote services. As an example, you get full transparency on the energy consumption of the cooling, and/or heating power delivered by the EV. Data is accessible from anywhere with an internet connection. Access to the Belimo online services also allows you to request the recommended individual settings for all the energy valves you own, and our servers base that recommendation on your valves individual historical data. As you'd expect, your data is encrypted and stored for the lifetime of the valve, or until you ask us for it to be removed.

Connecting the Belimo Energy Valve™ to the cloud can offer many benefits.

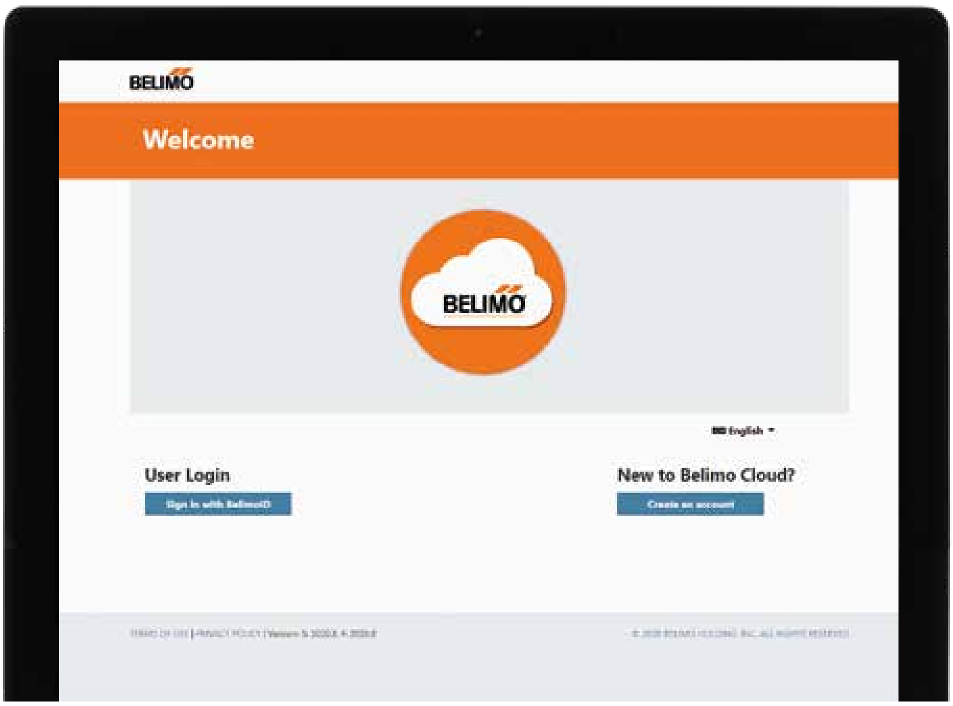


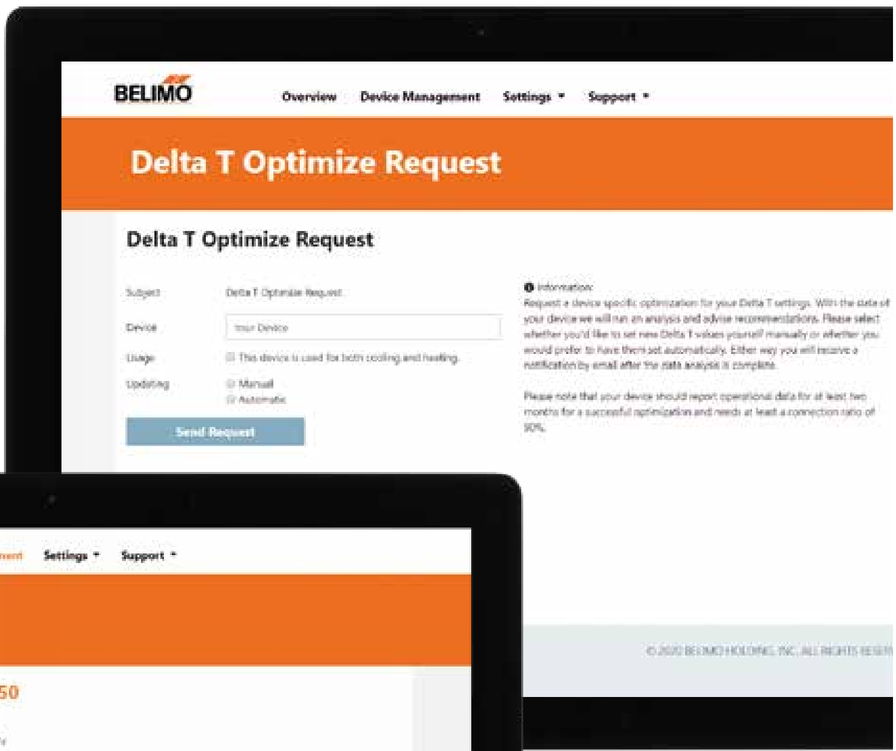
Figure 36: Easy login procedure to the Belimo Cloud and access to the EV's digital platform

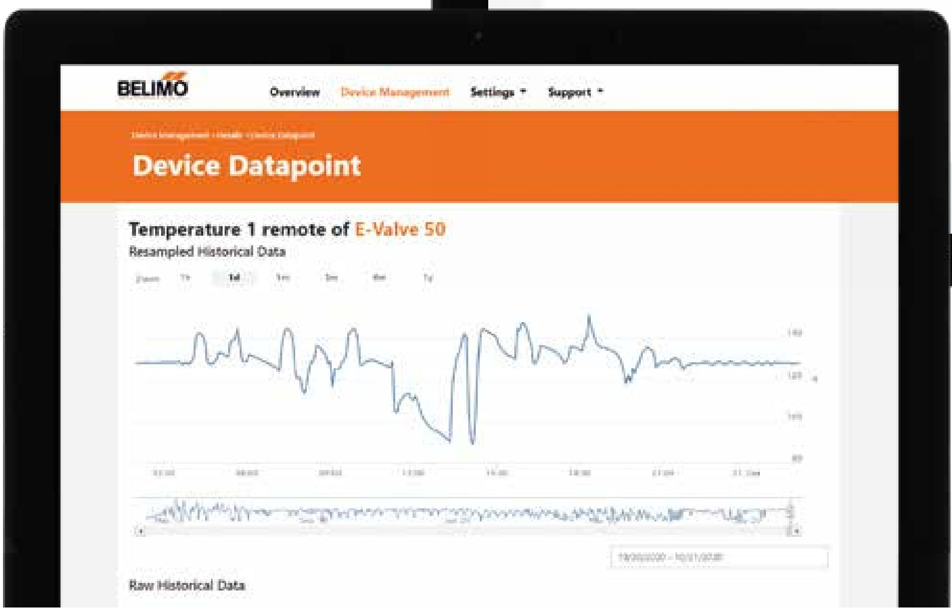
Your data, where you want it
As your EV data is already securely uploading to the cloud, your other favourite cloud-based services can be given permission to access your data, held by Belimo. We are working with hundreds of organisations, big and small, to ensure it's easy for them to make use of your data, should you request it.

Optimisation of delta T and flow settings
The data stored in the Belimo Cloud can be used to determine optimal flow and delta T setpoints, and can automatically set the valve for efficient operation or report the settings to the user. With the online form, as shown in figure 26, the user can send a request to Belimo to optimise the delta T and flow settings.

Figure 37: Online form to request the optimisation of delta T and flow settings

Figure 38: Once logged in, a series of services are available to the registered users





Performance reporting
If requested, each quarter, an EV performance report is generated and sent electronically to the owner of the Belimo Energy Valve™. The report contains important information on the operation of the EV. Energy usage and comparative analysis over previous years, along with operational data and possible errors in the system is included.

Online support
Being connected to the cloud gives the user the possibility to get online technical support, such as a personal live view of the valve operation and settings. Giving Belimo access to your data on a request-by-request basis allows quicker and more accurate diagnostics of the valve, and confirmation that the settings for the application are correct.


Belimo Energy Valve™

Performance Report

OVERVIEW

Reporting Period:	Q4, 2019
Name:	EV-AHU2_HKTC
Location:	Device location
Product:	NR24A-EV32A
Valve Size (DN-mm):	32
Report Generated On:	Jan 13, 2020 19:56

STATUS

The Energy Valve worked during the quarter, but warnings were reported. Read more about it on the second page.

CURRENT SETTINGS

Control Mode:	Flow
Override:	None
Maximum Flow (Vmax):	1.2 l/s
Installation Position:	Valve in return pipe
DeltaT Manager:	off

Please check out our DeltaT Optimization service.

ENERGY PERFORMANCE

Total Energy Q1-Q4, 2019:	23'556 kWh
Total Energy Q1-Q4, 2018:	24'582 kWh
Cooling Energy Q4, 2019:	3'878 kWh
Heating Energy Q4, 2019:	2 kWh

Figure 39: Example of an EV performance report

Software updates

Any firmware or software upgrades can be directly sent to the Belimo Energy Valve™. The settings allow for automatic download or notification with download on command. As on your mobile phone, the EV can always be updated with the latest security and performance enhancements.

Increase warranty to 7 years

If an EV is online and connected to the Belimo Cloud, the warranty of that valve will automatically be increased from 5 years to 7 years.

Lifetime data access

For online EVs, the key operational data will be permanently stored in the Belimo Cloud. On request of the owner of the valve, this data can also be deleted.

Figure 41: Overview of the EVs

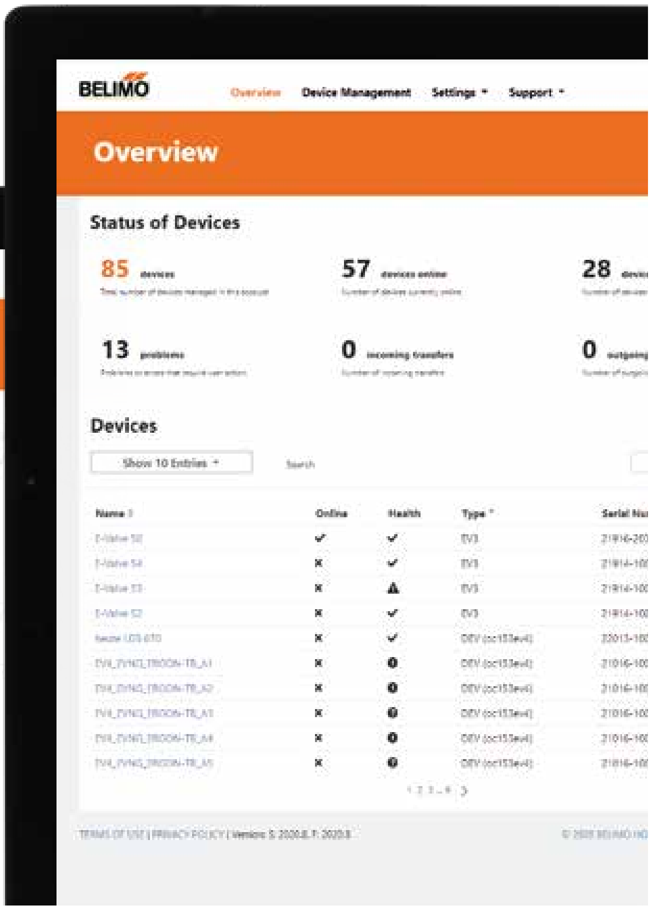
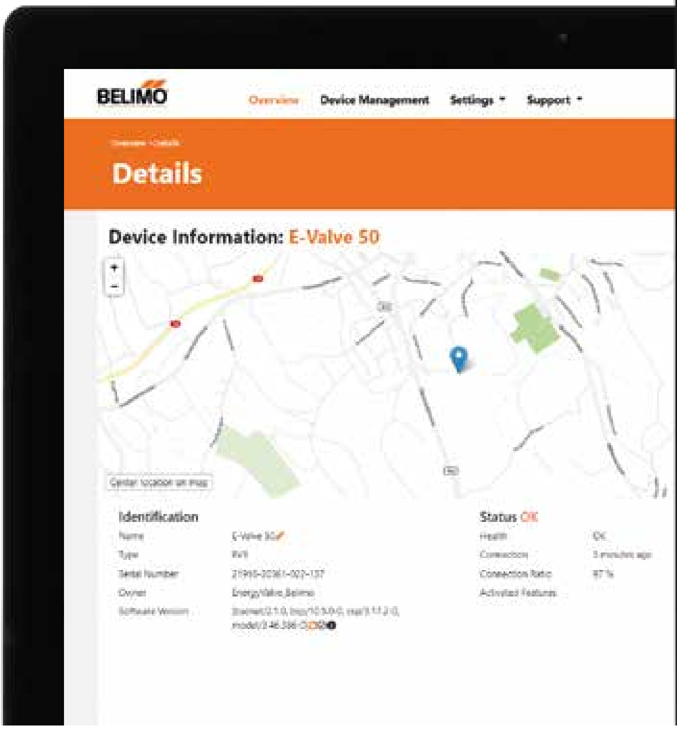


Figure 40: Device overview (online) for remote technical support



4.8 Belimo Digital Ecosystem

Figure 41 gives an overview of the Belimo Digital Ecosystem, which applies to all current and future Belimo devices that are, or will be, IoT ready. The EV is one of Belimo's devices that can be connected to a BMS and/or to the internet. The internet connection can be direct (via IP connectivity) or indirect (via a technician's mobile phone). Connected Belimo IoT devices will communicate with the Belimo Core Cloud, in which all essential data of an installed device is securely stored.

Client Application Programming Interface (API)
With explicit permission of the device owner, 3rd party IoT companies can be given access to data from devices connected to the Belimo Cloud through a Client API. This allows for an easy and seamless integration of Belimo device data to any other building IoT solution.

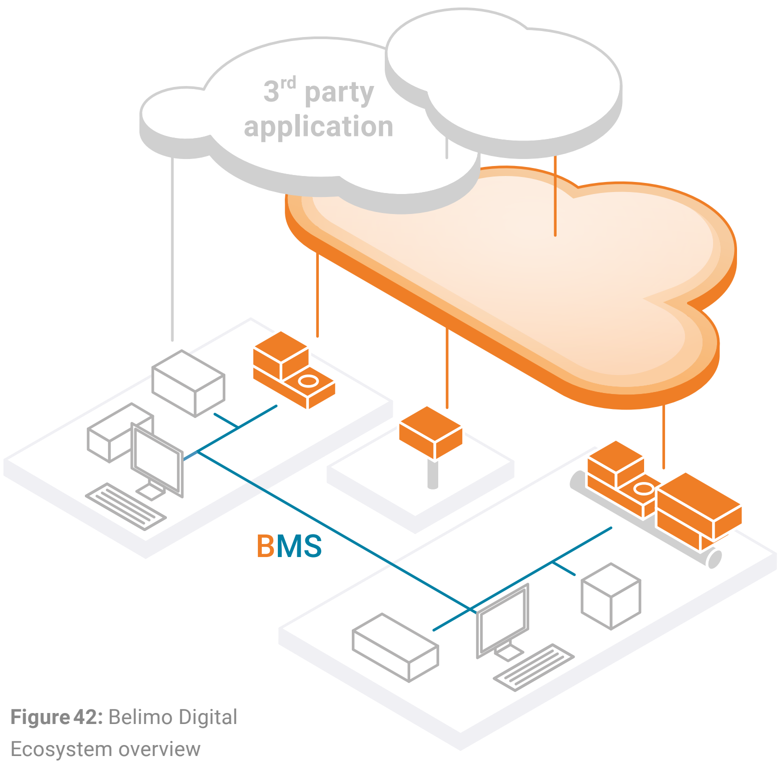


Figure 42: Belimo Digital Ecosystem overview

4.9 EV tools

A number of beneficial tools for the EV are available. For detailed information or training on these tools, contact local Belimo support.

Belimo Clear Edge™

The Belimo Clear Edge is an analytical on-premise network device that leverages the data from all installed Belimo Energy Valves™ in a BACnet-based building automation system (BAS). The Belimo Clear Edge technology is also available as a plugin for SkySpark.

The Belimo Clear Edge automatically visualises the Belimo EV data available in a local building network to optimise, manage, and monitor key performance indicators of water coil performance and hydronic energy consumption. The Belimo Clear Edge offers trending capability with automated delta T setpoint adjustment, to increase system performance and energy saving strategies. For this tool, an internet connection is not needed.

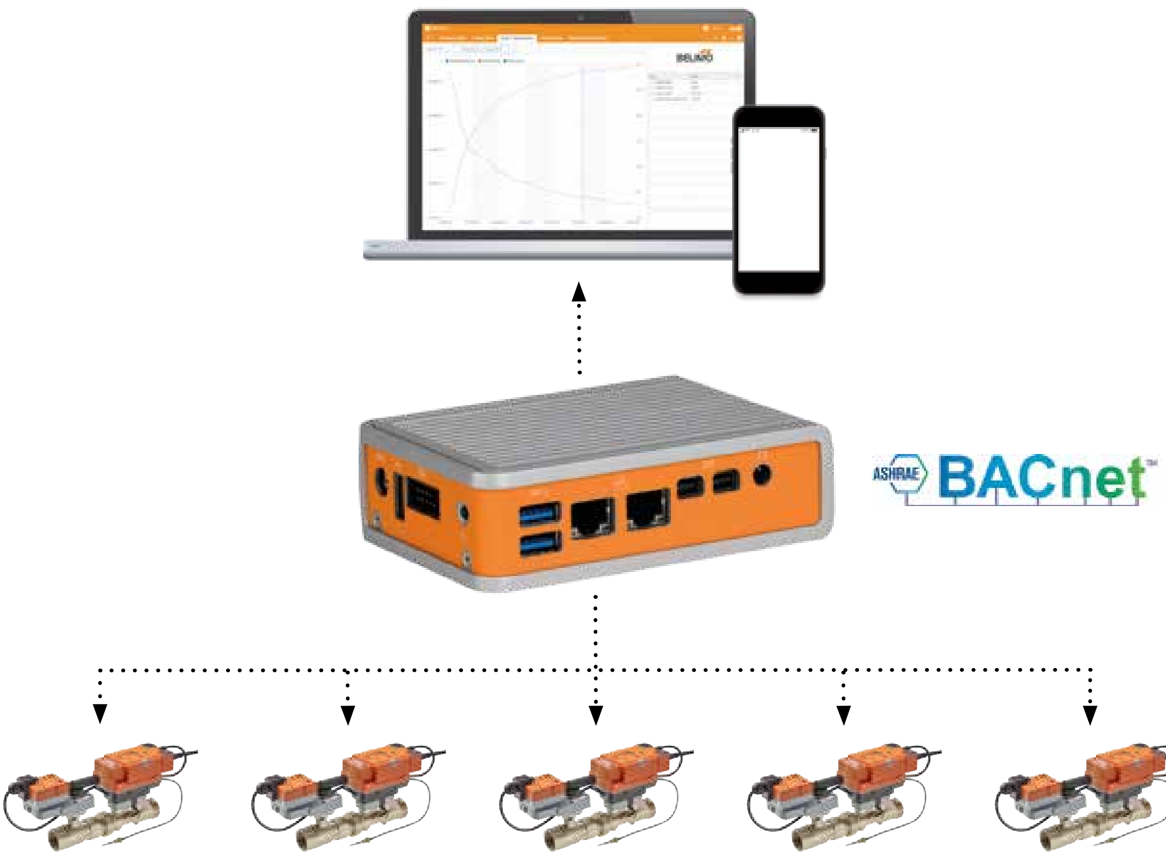


Figure 43: Belimo Clear Edge setup

Figure 44: EV Savings Estimator

EV Savings Estimator Tool

The Belimo Energy Valve™ Savings Estimator tool (Excel-based) compares current plant delta T against your delta T improvements from installing Belimo EVs, and calculates energy and cost saving benefits in an easy-to-read one-page format.

EV Data Analysis Tool

The Belimo Energy Valve™ Analysis Tool is used in conjunction with the Belimo EVs, to provide analysis of stored data, delivering efficiency and cost savings for your system. This tool can seamlessly import up to 13 months of trended data, along with performance metrics of a system, which all can be viewed graphically.

Get the most out of the EVs with the Belimo Energy Valve™ Data Analysis Tool, by viewing potential pumping savings using the Delta T Manager, which optimises the correct delta T setpoint based on coil operating conditions.

Figure 45: Data Analysis Tool

4.10 Energy Valve settings

	Position control	Flow control	Flow control DT fixed	Flow control DT scaling	Power control
V'max	–	Design flow rate	Design flow rate	Design flow rate	Design flow rate
P'max	–	–	–	–	Design power output
Delta T limiting settings	–	–	Fixed	Scaling	Fixed
Delta T limiting value	–	–	Coil designated delta T	Coil designated delta T	Coil designated delta T
Delta T flow saturation value	–	–	–	Flow associated with delta T limiting value or design flow V'max	–
Influence of the valve	Pressure fluctuations will directly impact the flow through the valve	Despite pressure fluctuations in variable flow systems, this mode will provide dynamic flow balancing	Despite pressure fluctuations in variable flow systems, this mode will provide dynamic balancing flow and fixed minimum delta T	Despite pressure fluctuations in variable flow systems, this mode will provide dynamic flow balancing and a range of minimum delta T for better performance	In this mode, the valve will control based on the power output requirements, regardless of pressure, flow and temperature fluctuations
Data collected	Real time flow, temperatures and power output	Real time flow, temperatures and power output	Real time flow, temperatures and power output	Real time flow, temperatures and power output	Real time flow, temperatures and power output

Pro Tip

Flow control already offers many advantages such as pressure independency.

You can take control to the next level by using power control. EVs are the only control valve to provide a true linear response between DDC signal and heat exchange output. You can go even further by selecting a delta T management option.

For existing buildings, it is recommended to leave the valve running for a short period to collect data, and to determine the correct values for flow saturation and the new delta T values. Data collected during this period can be used to optimise coil performance.

4.11 Summary of features and benefits of the EV

Feature	Benefit
Zero leaking/passing CCV valve	Circulation and energy losses are eliminated
Self-cleaning ball valve	Outstanding resistance to contamination and smooth operation even after prolonged closures
High resolution actuator	Enhanced controllability, even in low load situations
Pressure independent	Quick and safe valve selection according to flow rate No calculation of flow coefficient (Cv/Kv) Ideal room comfort due to correct flow rate at any time
Automatic and permanent hydronic balancing	Fast commissioning, no balancing valves, or measuring stations needed
Connection to the Belimo Cloud	Delta T management by experts from Belimo Transparency due to regular performance reports Remote maintenance and diagnostics Support via Belimo Cloud Free software updates Data storage over the entire life cycle Extension of warranty to 7 years
Compact size	Maximum efficiency in space and design freedom
Variable V'max setting	Highest flexibility during planning, installation and use phase
Pressure independent flow rate due to dynamic balancing	Mechanical commissioning is reduced to read and recording flows
Accurate flow measurement	Real time flow rate information
Glycol measurement	Continuous measurement offers certainty over glycol concentration; a BMS point can be alarmed if concentration deviates
All-in-one solution	5 functions: measuring, controlling, dynamic balancing, isolating and energy monitoring
Power control	Temperature and differential pressure independent control of the power to a coil
Delta T Manager	Avoidance of low delta T syndrome Removes overflow and saturation operation of the heat exchanger in the presence of insufficient temperature spread Efficient operation of pumps and heat generator or cooling machine
Recording of all system data from the past 13 months	Full system transparency indicates optimisation potential Changes in the system performance are evident Ensures preservation of value of the entire system Aids with system troubleshooting

5

Feature Overview of the new Belimo Energy Valve™ 4

In 2021, Belimo launched a totally new generation (4) of EVs in the sizes between DN15 to DN50. This new EV range includes a certified thermal energy meter with a number of highly innovative features. The meter also contains the logic to drive the attached CCV valve, available both as fail-safe or non-fail-safe options. The certified meters are also available as 'standalone' devices, without the valves.

5.1 Key features at a glance

In 2021, Belimo launched a totally new generation (4) of EVs in the sizes between DN15 to DN50. Energy Valve 4 now offers an optional certified thermal energy meter, along with a number of other highly innovate features. The meter also contains the logic to drive the attached CCV valve, available both as fail-safe or non-fail-safe options. The certified meters are also available as 'standalone' devices, without the valves.

Thermal energy meter

Certified energy metering with MID approval
The thermal energy meter meets the requirements of EN1434, and has type approval according to the European Measuring Instruments Directive 2014/32/EU (MI-004).

Energy cost billing
Thanks to its compliance with EN1434/MID, the meters can be used for billing of energy consumption to tenants. This is a mandatory requirement in many countries.

Digitally supported workflows
The Belimo Assistant App guides you through the setup process.

Power over Ethernet (PoE)
The devices can be connected with one standard PoE/Ethernet cable that provides power and data transmission.

Easy integration
Using BACnet/IP & MSTP, Modbus TCP & RTU, the thermal energy meter can be integrated directly in the building management system. No extra communication gateway is required.

IoT-based billing
Thanks to the embedded web server, the thermal energy meter can be securely connected to the Belimo Cloud. From there, authorised 3rd party billing services platforms can access the available energy data and use it for tenant billing.

Belimo Energy Valve™ 4

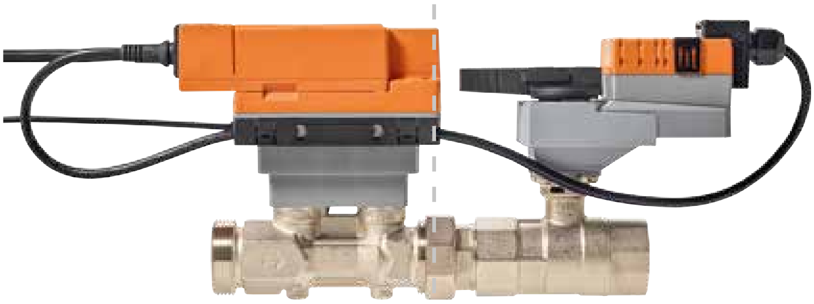
Energy monitoring
The EV accurately measures and logs the thermal energy supplied to the coil. The logged data helps to identify areas for optimisation.

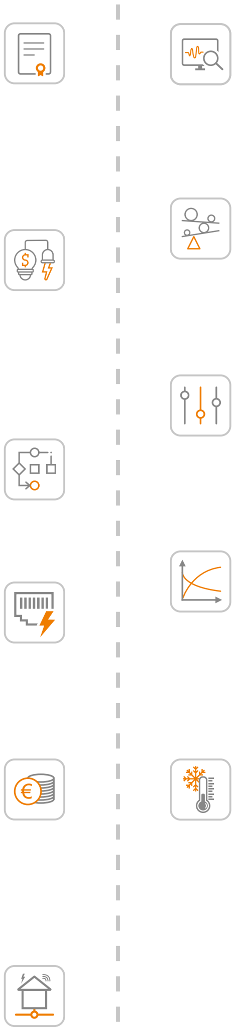
Automatic balancing
Hydronic balancing is no longer needed, thanks to the pressure independent flow control of the valve.

Power control
By measuring temperature and volumetric flow, the EV controls the real power provided to a coil, according to the setpoint.

Delta T management
The integrated logic prevents the occurrence of the low delta T syndrome, and ensures maximum comfort with the lowest possible energy consumption.

Glycol measurement and compensation
Belimo's patented glycol measurement and compensation guarantees precise energy metering at all times. With MID certified heating power measurement, where glycol is not permitted, an alarm is triggered upon detection presence of glycol.

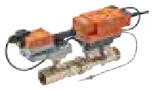




5.2 Generation overview

Since its release in 2013, the functions and the performance of the EV have been continuously expanded. The table below shows the evolution of the EV over time, over 4 product generations.

Belimo Energy Valve Generations

		1	2		3		4
Release Date		**2012**	**2014**		**2017**		**2021**
Internal Thread	DN 15 - 50						
Flange	DN 65 - 150						
Control Mode	Position	■	■	■	■	■	■
	Flow	■	■	■	■	■	■
	Power	■	■	■	■	■	■
Delta T	Fixed	■	■	■	■	■	■
	Scaling		■	■	■	■	■
Belimo Cloud					■	■	■
NFC Assistant App							■
Glycol Measurement					■	■	■
MID Approval							■
NIST Traceable					■	■	■

5.3 Reliable certified metering, enabling IoT-based billing

High quality measurement
Belimo thermal energy meters use ultrasonic transit time technology, and it is dirt resistant, wear-free, and able to detect air in the water, as well as offering very precise measurement by using a fast measuring cycle. Our multi-point wet calibration of each individual meter in production ensures high accuracy over the entire flow measurement range.

Multi-application device
Belimo's thermal energy meters are designed to be multi-application devices, ie. they can be used as heat meters, cold meters, or combined heat/cold meters. They can be installed either in the return from, or in the supply to, heat exchangers. The application and installation positions are provided to the valve during setup, using a smartphone and the Belimo Assistant App, or using a laptop and the built in web server.

Certified energy metering
Belimo's certified thermal energy meter models meet the requirements of EN1434, and have type approval in accordance with the European Measuring Instruments Directive 2014/32/EU (MID). This certification is a precondition, or in some countries, a mandatory code that is good to be aware of, if you intend to use meters for energy billing or for heat-cost allocation to tenants. They provide validated data for invoicing purposes, which can be used for direct invoicing. The thermal energy meters are approved according to MID for heat metering in pure water systems. In order to comply with MID requirements, we are unable to compensate for glycol in the water. However, the device is able to offer an alarm if it's detected.

Accurate thermal meters without certification
It is not commonly known that glycol in a hydronic system can falsify the thermal energy measurement up to 30%. Belimo's meters (non-MID versions) have the unique capability to measure thermal energy accurately and reliably, even with the presence of glycol. The ultrasonic technology and a patented algorithm recognises the type of glycol and its concentration, and automatically compensates the energy measurement to the correct value.

Simplified energy billing
The thermal energy meters and the Belimo Energy Valve™ are ready for remote meter readout and IoT-based billing. Authorised users can access the measured energy data, either via the bus (BACnet, Modbus) or via the meter's IoT interface on the Belimo Cloud. From there, the metering data can be made available to other authorised platforms. This gives building operators maximum flexibility when choosing the energy billing service provider. This high quality data can be used for various other applications.

5.4 Digitally supported commissioning workflow

Simple commissioning and activation through NFC

The NFC (Near Field Communication) interface on the thermal energy meter enables easy commissioning, configuration, and maintenance directly from a smartphone. With the Belimo Assistant App, devices can be configured intuitively, and the final configuration and activation is securely logged. Optionally, your smart phone can act as the devices' gateway to the cloud, where the settings are stored for the lifetime of the device. Key performance indicators of the meter and valve, also visible on the app, make it easy to determine the 'health status' of the device and ensure reliable long-term operation.

Troubleshooting using NFC

Our devices provide numerous diagnostic parameters to the assistant app via the NFC interface, allowing you to see how it interacts with the system during operation; making this your go-to tool during troubleshooting. As an added benefit, you can get direct support for your device by using your smartphone to upload your devices' data to the cloud. With your permission, Belimo engineers can look at the data and help with your troubleshooting.

Connected, secured, and working for you – what a cloud connection can do

Alongside the usual integration of meters and EVs to a BMS (via BACnet or Modbus), they can optionally be securely connected to the Belimo Cloud. Cloud connection offers several additional services to users authorised by the device owner, over and above the storage of past performance, energy consumption, power requirements and delta T. For example, when requested, our servers can analyse historical flow and temperature data for recommending the ideal delta T setting, allowing for an even more energy-efficient operation. Online software updates ensure that the device is always up-to-date and secure.

Modular design – makes re-calibration and replacement easy

The thermal energy meter consists of two main parts, (a) the sensor module with the connected temperature sensors and the integrated calculator, and (b) the logic module with the NFC interface and all the connectors for the external power- and bus-wiring.

The sensor module is available as a spare part and, in certain countries, must be periodically replaced for re-calibration according to national regulations. In this case, only the lower sensor module must be exchanged. The upper part with all electrical wires remains connected and no new integration work is needed. This is a significant labour saving in the maintenance cycle of the meter.

Pro Tip

Should it be required, NFC can be permanently disabled.

Figure 46: All wiring is to the logic module, allowing the EN1434/MID sensor module to be re-calibrated without disturbing the wiring

5.5 Seamless integration of metering data – with a totally open approach

Easy integration to the BMS or metering systems

Connectivity has always been an important feature of our products. The Belimo Energy Valve™ and the thermal energy meter supports a number of building automation protocols (BACnet IP and MS/TP, Modbus TCP and RTU, Belimo MP-Bus, and M-Bus via a converter). Parallel operation of BACnet IP or Modbus TCP with M-Bus (with converter) is also possible. Bus communication can also be used for monitoring, controlling and even overriding when using an analogue signal to control the Belimo Energy Valve™.

Power over Ethernet (PoE)

The Belimo Energy Valve™ 4 and the thermal energy meter 4 are the first Belimo products coming on the market with PoE connectivity. This allows the device to be powered, and the data to be transmitted simultaneously with one single Ethernet cable. This simplifies installation, avoids wiring errors and eliminates the need for a local power supply. As PoE is extra-low voltage, below 50 Volts, wiring does not necessarily have to be carried out by a certified electrician.

Integration into any building IoT platform

Belimo's IoT-ready products, such as the thermal energy meter and the Belimo Energy Valve™, can optionally be connected to the Belimo Cloud, and from there, to other authorised 3rd party building IoT platforms or energy-analytics applications. Now you or you customers can benefit from the possibilities of a networked digital ecosystem.

- Take full control of your data
- Implement effective optimisation and energy-saving strategies in buildings
- Reduced maintenance costs
- Always vendor independent, allowing you to select any BMS and energy billing providers, and change them later
- Work with your securely stored and transparent device, and store data over the entire plant lifetime

5.6 Available Belimo thermal energy meters 4

The new Belimo thermal energy meters 4 are currently available in sizes ranging from DN15 to DN50. Depending on the application and the national codes, MID approved or non-MID approved Belimo thermal energy meters can be selected. The MID approved meters meet the requirements of EN1434 and have type approval according to the European Measuring Instruments Directive 2014/32/EU (MID). This is mandatory for heating applications in many countries, ie. most of the member states of the EU, where the measured energy data is used for direct billing or heat cost allocation to tenants.

Thermal energy meters without MID approval can used in all heating or cooling applications where no tenant billing is foreseen, or in countries where no mandatory codes on energy cost billing exist. This type of meter is particularly useful in cooling systems where the systems are to be operated at sub-zero temperatures, and therefore work with water-glycol mixtures. In this case, the thermal energy meters automatically and continuously measure the glycol content of the fluid, and compensate it to ensure that the thermal energy can always be measured reliably.

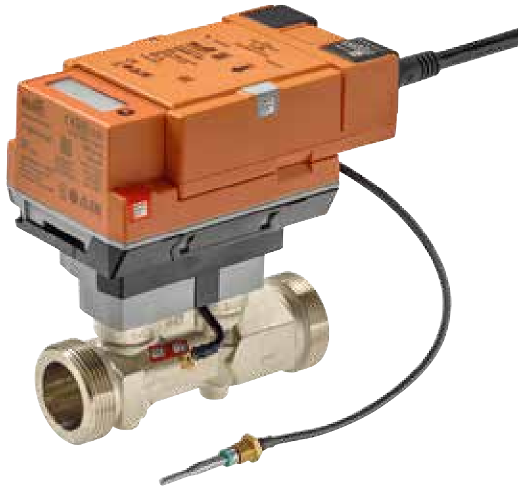


Figure 47: The Belimo thermal energy meter 4

Available Belimo thermal energy meters 4

Version	Type code	Autom. glycol compensation	Glycol alarm	Approved according to EN1434/MID	Display	Nominal diameter DN	Nominal flow [m³/h]
With meter display	22PEM		■	■	■	15...50	1.5...15
Without meter display	22PE	■					

5.7 Total system optimisation with Belimo Energy Valves™

If you plan to use Energy Valves throughout the building, you will have a lot of data, and that data can be used to help provide building optimisation. With all the products on the market, it can often be challenging to design a holistic system that offers genuine energy savings. Making use of the energy saving strategies described in this guide, requires multiple data points from the valves, therefore a bus connection is required, and the network implemented should be able to provide timely data to the BMS, allowing it to react as quickly or as slowly as is required.

Common Problem: Pump optimisation using mechanical PI valves
Mechanical PI valves have a regulator or diaphragm that alters the pressure drop across the valve. This continuous adaption of the valves Cv/Kv ensures it has a perfect valve authority, however, it means that valve positions are no longer related to the pressure drop of the circuit.

A typical solution involves using pressure sensors to control pump speeds, detection of pressure changes caused by movement in valves or diaphragms, and pump speeds altered accordingly. However, positioning of these sensors is troublesome. Too close the pumps and you cannot take advantage of the friction losses in the pipe at lower flows, and too far in the field, you risk the index shifting to a different point in the system from physical or seasonal changes.

Solution: Pump optimisation using electronic valves
As there is no diaphragm, the position of an electronic valve is an indication of flow and pressure. A valve with a small degree of rotation indicates it has a lot of pressure and is satisfied. A valve in a fully open position is unable to satisfy the current flow requirement with the available pressure.

When you understand Energy Valves don't throttle flow, but they only throttle overpressure from the pump, optimisation becomes easy. Using a BMS to sense, and work with these position values, you can offer total optimisation. Simply, poll for the furthest open valve, which is your 'index', slow the pump down until that valve opens to a specified point, for example, 90%, then once in this position, the pump is only working just hard enough to deliver the correct flow to the whole system.

Now, if the index shifts in a building, either from a change of season, changes to or extensions of the hydronic system, or occupant use patterns, you are ready for it.

Figure 48: An Energy Valve that is not satisfied with its flow requirement, and is experiencing insufficient differential pressure

Figure 49: An Energy Valve that satisfies its flow requirement, and is experiencing low differential pressure

Figure 50: An Energy Valve that satisfies its flow requirement, and is experiencing high differential pressure

Problem: Chiller plant optimisation without active delta T management
Chillers consume much more energy than pumps, so it makes sense most efficiency projects start there.

Chillers often come with built-in optimisation. Software in most other HVAC energy-saving products work by assuming that this is the only optimisation taking place in the system. Often multiple systems conflict, leading to disappointing results.

As an example, a system that adjusts flow temperatures based on delta T at the plant, is misled by multiple AHUs offering significantly different delta T. An addition of Energy Valves™ will harmonise the delta T, however, the central system then cannot detect any system changes as the delta T is now uniform.

Solution: Using active delta T management while optimisation flow temperatures
Delta T Manager scaling on the heat exchangers offers a great solution of permitting low delta T at low flows and enforcing design delta T at design flows. However, the missing piece is communication between the valve and the plant control. Typically, your plant cannot detect that a valve is only half-open, not because there is a lack of demand, but because the Delta T Manager is holding at 50%, as higher flows results in coils becoming inefficient.

A simple solution is to poll the valves for the control signal DDC they are currently using. The valve with the highest control signal DDC is the 'thermal index' flow. Temperatures can be scaled on the position of that thermal index.

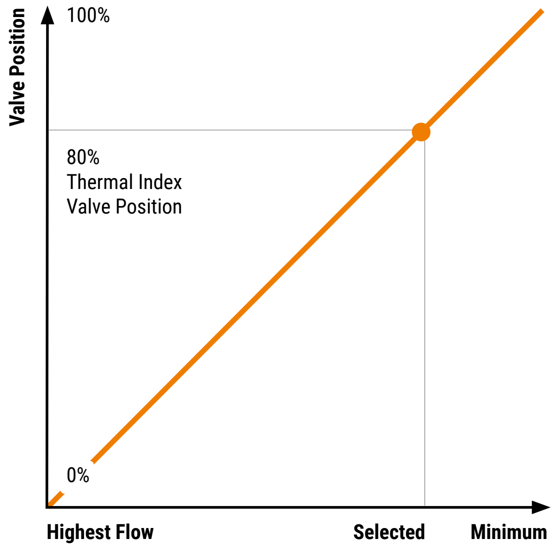


Figure 51: A simple method of selecting flow temperature based on thermal index valve position

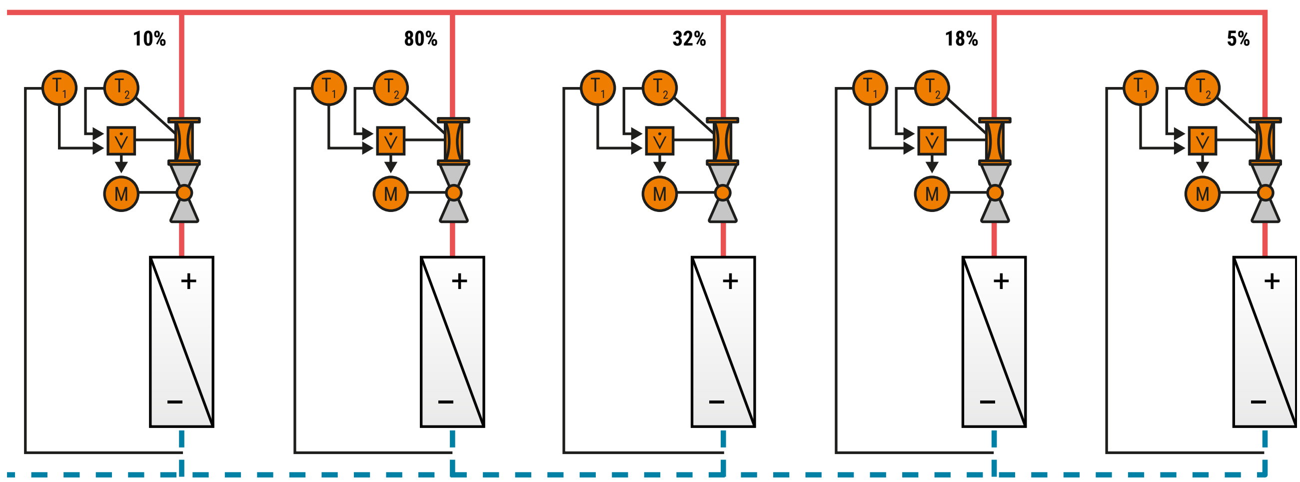


Figure 52: The thermal index of the most open valve, which is selected by the BMS

Problem: Secondary energy savings, by short cycling the primary circuit through the hydronic separator
Hydronic systems are often split into two, a primary circuit serving the main plant, and a secondary circuit that carries the energy out to the field. We do this as our primary plant has a minimum flow requirement. If the secondary flow is below the minimum flow requirement of the primary, we see a flow through our separator. Most modern systems are variable flow on both sides, however, legacy systems have a fixed speed primary. Often when we 'optimise', we are focused on the secondary, but only optimising the secondary can simply short cycle the primary.

Possible Solution: Monitor flow through your separator and delta T of the primary using an Energy Valve
By monitoring the flow through the separator, we can programme the BMS to do something about unwanted separator flow. For example, you could allow the chilled water reset to take the thermal index valve to 100% open, or choose to starve that index valve. You could even elect to overflow a number of valves to ensure the secondary flow remains above the primary minimum.

It's also worth programming an alarm. If you have separator flow, when there should be none, you can investigate the cause.

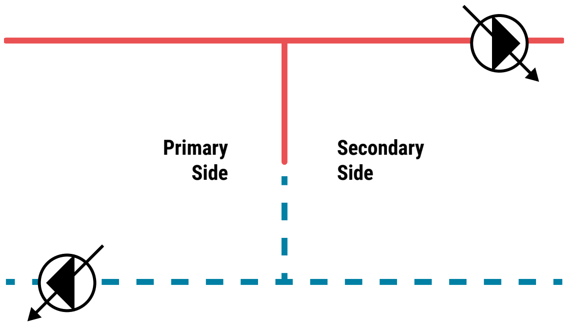


Figure 53: A simple depiction of a primary/secondary circuit with a hydraulic separator

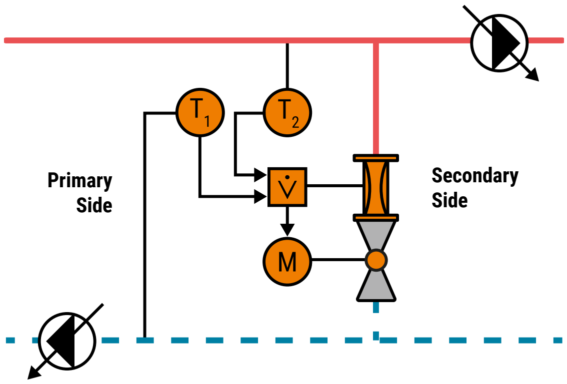


Figure 54: An Energy Valve monitoring the temperature spread of the primary, and flow through the separator

Pro Tip

If your chilled water separator pipework is very large, you can use a thermal energy meter in the secondary return, which is generally smaller, and a characterised butterfly valve in the separator. Most chillers will report the flow through them, allowing the total to be compared to secondary return. It requires a few separate components, and a bit more setup, but delivers significant energy savings.

5.8 Belimo Energy Valve™ 4

The new generation of Belimo Energy Valve™ 4 are currently available in sizes from DN15 (1/2”) to DN50 (2”). For larger sizes from DN65 (2.5”) to DN150 (6”), the current Belimo Energy Valves™ 3 are used. This offers the same base functionalities such as electronic pressure compensation, power control, delta T management and IoT connectivity. Product variants are available for 2-way or 3-way non-diverting applications, and with fail-safe or non-fail-safe function. Depending on the desired application, the requirements according to EN1434 are met with a type approval according to the European Measuring Instruments Directive 2014/32/EU (MID), or devices with automatic glycol compensation are available, all of which enable accurate metering.

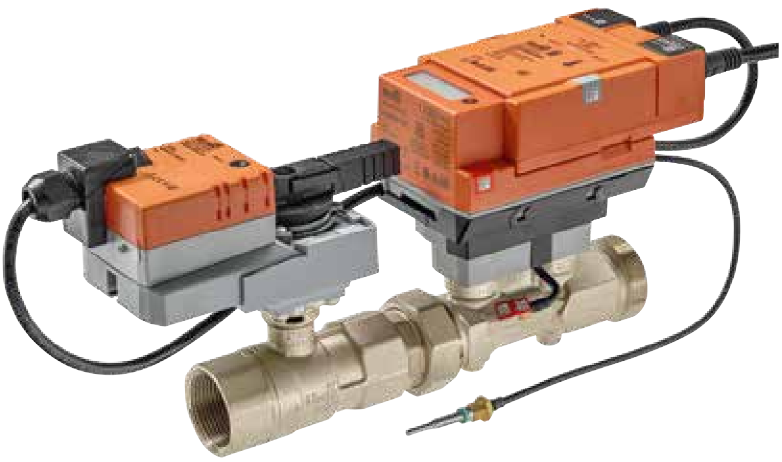


Figure 55: The Belimo Energy Valve™ 4

FEATURES

- Integrated sensors for measuring the temperature spread, the flow and thereby the power
- Regulation of the valve position, flow or power, for optimal operation of the heat exchanger
- Automatic compensation of differential pressure changes during partial load operation
- Uses Belimo CCV 0% leakage technology, offering complete piece of mind
- Ready for IOT-based billing
- Simplified setup and configuration with the Belimo Assistant App
- Seamless integration in the building management system via bus communication
- Device can be powered and data can be transferred directly via an Ethernet cable (PoE)

Available Belimo Energy Valves™ 4

Version	Type code	Autom. glycol compensation	Glycol alarm	Approved according to EN1434/MID	Display	Nominal diameter DN	Adjustable flow V'max [l/min]
2-way	EV..R2+BAC	■				15...50	6.3...288
	EV..R2+KBAC	■					
	EV..R2+MID		■	■	■		
3-way	EV..R3+BAC	■					

Energy Valves sized DN65 to DN150 are available as Belimo Energy Valve™ 3

SPACE FOR NOTES

PART B

Belimo Energy Valve™ HVAC Applications

Part B of this handbook presents a selection of common HVAC applications in which the Belimo Energy Valve™ comes into use. After a short description of each application, common reasons for poor efficiency or performance are identified. There is an explanation of how the EV addresses these problems, and which control modes and settings are recommended to achieve optimal performance.

Keep in mind that this application handbook only provides general guidance for the use of the EV, and that this does not substitute for the work of a professional engineer.

Quick Selection of Valve Control Mode

Based on our application experience, we propose setting up your Belimo Energy Valve™ as shown in the table below. Details can be found in the examples on the following pages.

○ INITIAL SETUP
● EXPERT CHOICE
■ EXPECT CHOICE
(if demand Power known)

CONTROL MODE		POSITION CONTROL	FLOW CONTROL	FLOW CONTROL WITH DELTA T MANAGER	FLOW CONTROL WITH DELTA T MANAGER SCALING	POWER CONTROL WITH DELTA T MANAGER	PAGE
1	Air Handling Unit		○			●	64
2	District Heating or Cooling/Plate Heat Exchanger		○			●	72
3	Fan Coil Unit		○		●	■	78
4	Chilled Beam		○		●	■	86
5	Two Pipe Change Over		○		●		92
6	Branch Flow and Delta T Control		○		●		96
7	Computer Room Air Conditioner		○			●	102
8	Central Heating Plant	●					106
9	Chiller/Heat Pump Monitoring	●					112

1

Air Handling Unit

1.1 Application description

An air handler or air handling unit (often abbreviated to AHU) is a machine used to condition and circulate air as part of a heating, ventilating, and air-conditioning system. An air handler usually contains one or more fans, heating and/or cooling heat exchangers, filter racks or chambers, sound attenuators and dampers. Air handlers usually connect to a ductwork ventilation system that distributes the conditioned air through the building and returns it to the AHU. Water is delivered from the central plant to the AHU, and is passed through a heat exchanger. This process is controlled by a DDC control loop, which adjusts the water flow through the heat exchanger using a control valve. The valve is modulated by the DDC that maintains a desired temperature either in a space or leaving the AHU. Figure 56 shows a schematic of the heat exchanger control within an AHU, which uses a Belimo Energy Valve™.

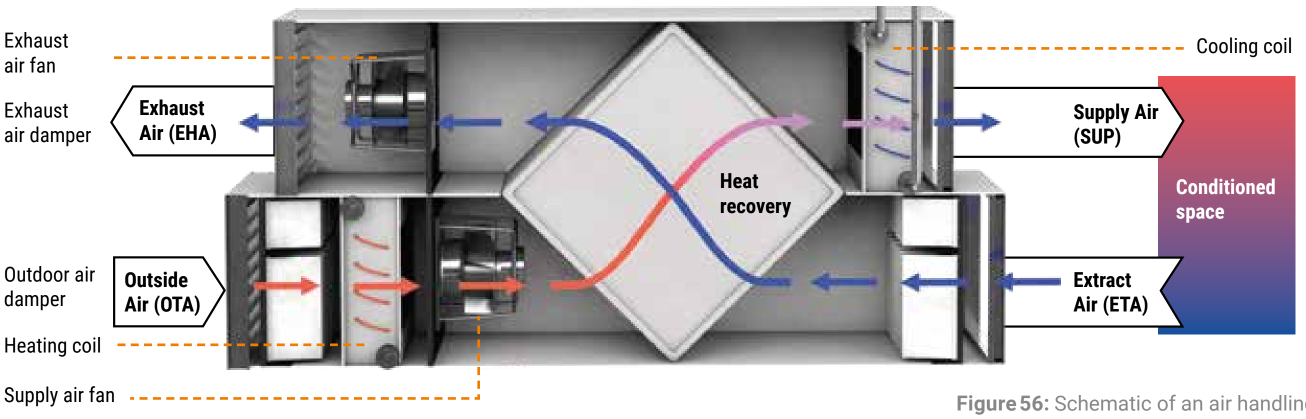


Figure 56: Schematic of an air handling unit (AHU)

1.2 Schematic

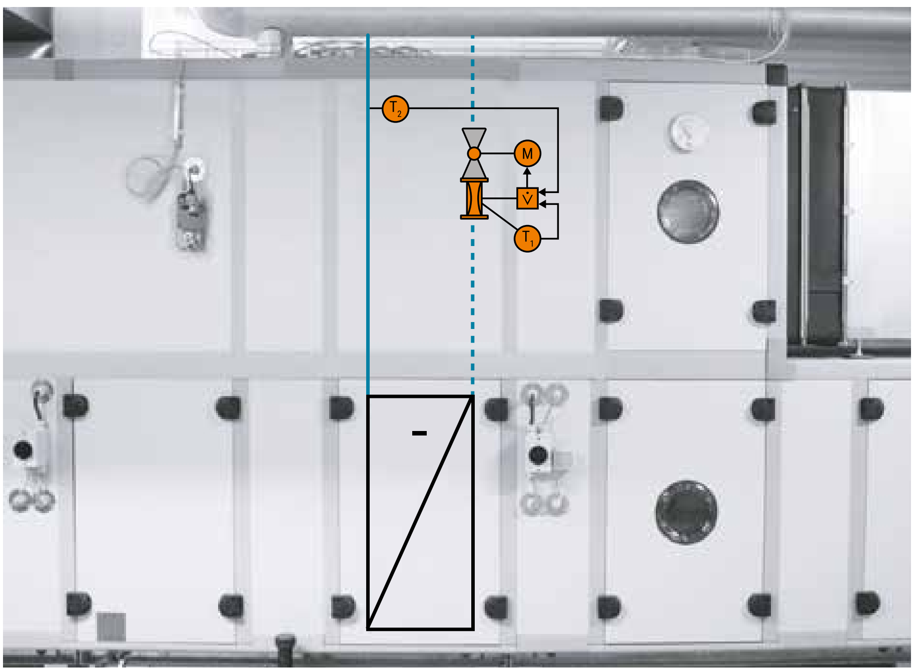


Figure 57: Example of a typical air handling unit (AHU) cooling coil with EV

1.3 Common issues in AHU applications, and how the Belimo Energy Valve™ addresses them

Many AHUs in the field suffer from poor performance, principally for the following reasons:

- Part load: Dynamically changing water and air flow rates results in mismatches, and these lead to overflows and low delta T.
- Coil performance: Coils degrade over time. Without proper maintenance, the coil output is reduced, leading to lower heat transfer.
- Oversized valves: Pressure dependent valves that are oversized are most commonly selected using line size. This oversizing creates control instability by delivering large changes in water flow for small valve movements.
- Bypass or diverting 3-way valves: Reject water not required by the heat exchanger back to the central plant. This has a significant negative effect on central plant efficiency, and requires large amounts of pump energy.
- Pressure fluctuations: Differential pressure fluctuations substantially impact the flow rate through the coil.

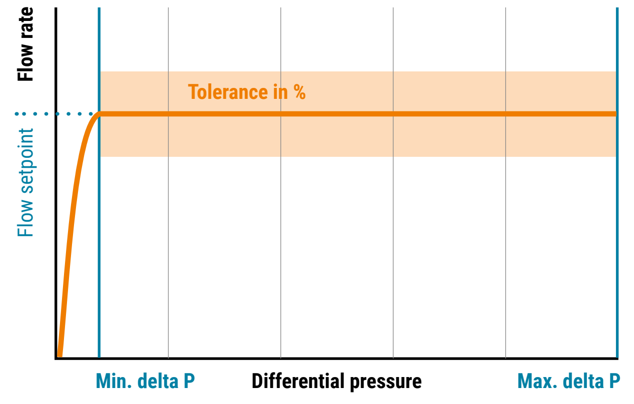


Figure 58: Dynamic balancing assures an accurate flow rate

1.4 Applying the Belimo Energy Valve™

Problem: Water pressure fluctuations result in poor performance
Loads in the buildings often change dramatically based on the season, and even throughout the day. However, static balancing is undertaken based on worst case 'design loads'. As buildings rarely experience 'design load', DDC controls have to continually adapt the water flow through the heat exchanger, depending on the actual demand. These continuous adaptations create pressure changes for the other heat exchangers in the same hydronic circuit and negatively influence their flow rates.

Solution: Dynamic balancing
Reciprocal influence of several consumers in a hydronic system can be completely eliminated with the dynamic balancing function of the EV. Changes in differential pressure do not cause any changes in the rate of flow.

Problem: Low delta T syndrome
AHUs typically control air volume based on duct static pressure, and water flow rates using outlet air temperatures. As the relationship between valve position and air volume is not fixed, the dynamic nature of the control means that the air volume is regularly mismatched to the water flow. This often results in overflows, which we know as low delta T syndrome.

If a heating or cooling system is operated with excess water flow, this cannot be converted into higher heating or cooling power. In this case, the temperature spread between supply and return decreases. The resulting low delta T syndrome is a clear indicator that the pumps are working harder than they need to, and central plant capacity is compromised.

Solution: Delta T Manager
The Delta T Manager, integrated in the Belimo Energy Valve™, is a function that continuously measures the temperature spread and compares it with the system-specific limiting value. If it falls below this, the Belimo Energy Valve™ automatically adjusts the flow so that only the amount of water actually needed to achieve the desired power is used. As a result, the integrated logic prevents the occurrence of low delta T syndrome and ensures maximum comfort with the lowest possible energy consumption.

For more detailed information about delta T syndrome and the Delta T Manager see chapter 4.4.

Summary of main EV advantages in an AHU application

- Dynamic balancing by the Belimo Energy Valve™ ensures the correct amount of water at full and partial load.
- Reciprocal influence between valves is eliminated due to the dynamic balancing.
- Power control delivers identical heating or cooling output for any given input.
- The monitoring capabilities of the EV provides full system transparency (volumetric flow, temperatures, and cooling/ heating output) with data recording and optional archiving to the Belimo Cloud.
- Constant pump optimisation is possible using the physical valve position.

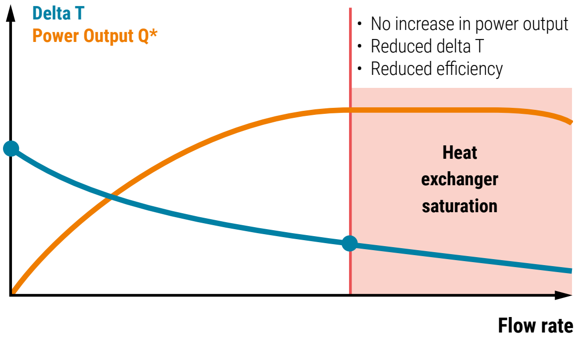


Figure 59: Low delta T syndrome

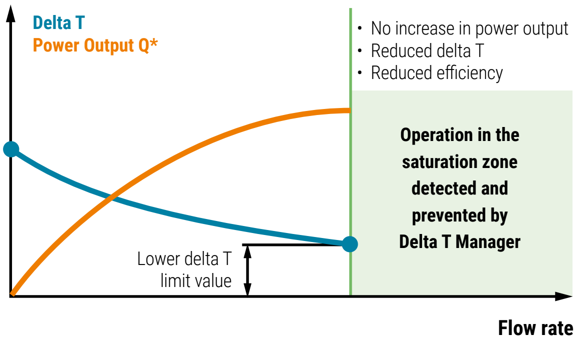


Figure 60: Improved energy-efficiency with the Energy Valves™ Delta T Manager enabled

1.5 Application example

Problem: Poor performance, low delta T and overflow

As depicted in figure 61, a VAV Air handling unit serves a cooling load to a number of VAV boxes. It is loaded up with a high outside air temperature, and requires the fan and valve to run near maximum.

As the day continues, the well sized and setup AHU starts to overcome the load in the space. This results in the VAV boxes reducing their damper position with the fan slowing, as a result of the increase in static pressure.

As a result of the outside air temperature still being very warm, the DDC controller still keeps the valve open, requiring 3.0 l/s [45 GPM] to maintain the supply air temperature.

But, as we no longer have design air volume, it is impossible to know what the correct water flow should be, unless we are looking at the delta T. Also, as other AHU valves back off, system pressure increases, overflowing the AHU in this example with 3.5 l/s [55 GPM].

As a result of the overflow, the delta T of the coil drops to 2 K from 7 °C [12.6 °F] to 9 °C [16.2 °F], putting the heat exchanger in the saturation zone. However, the DDC cannot detect this from supply air temperature, which remains relatively unaffected, as shown in figure 61.

Applying the EV: Dynamic balancing and Delta T Manager

Figure 62 shows the same VAV air handling unit with an EV installed, which serves a number of VAV boxes loaded up with a high outside air temperature that requires the fan and valve to run near maximum.

As the day continues, the well sized and setup AHU starts to overcome the load in the space. This results in the VAV boxes reducing their damper position with the fan slowing, as a result of the increase in static pressure.

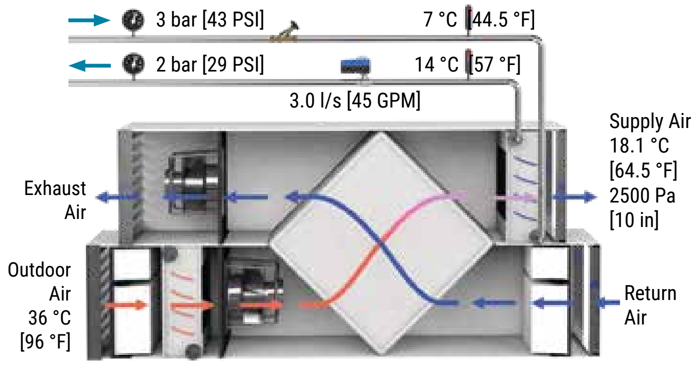


Figure 61: AHU at design operation

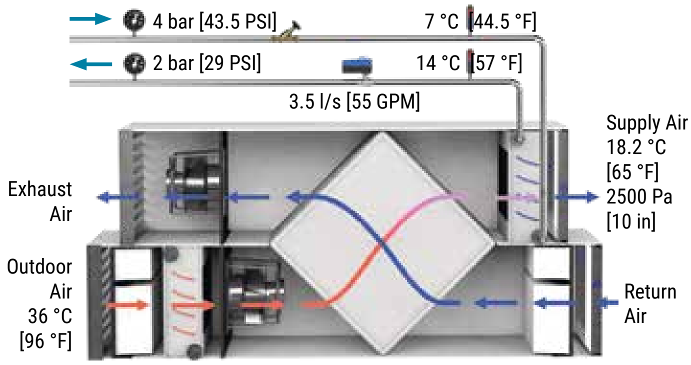


Figure 62: AHU with valve overflowing

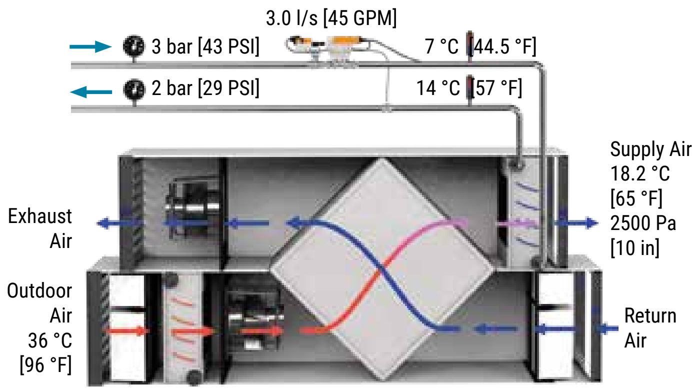


Figure 63: AHU at design operation

As a result of the outside air temperature still being very warm, the DDC controller still keeps the valve open, requiring 3.0 l/s [45 GPM] to maintain 7 Kelvin design delta T of the coil from 7 °C [44.5 °F] to 14 °C [48 °F].

But, as we no longer have designed air volume, it is impossible to know what the correct water flow should be, unless we are looking at the delta T.

As shown in figure 64, even with 2.7 l/s [43 GPM], the return temperature would be too low, giving us a delta T of only 2 K.

The Energy Valve, with Delta T Manager active, recognises the delta T reduction and overrides the control signal DDC to maintain the specified delta T across the coil. In this case, the Delta T Manager adapts it towards the design of 7 K by reducing the flow to 0.8 l/s [13 GPM], as shown in figure 65.

With the Delta T Manager active, the Energy Valve™ dynamically manages flow based on the delta T and the DDC setpoint. This allows more flow up to the DDC required, by increasing delta T, and reduces flow until a minimum flow is reached should the delta T fall further.

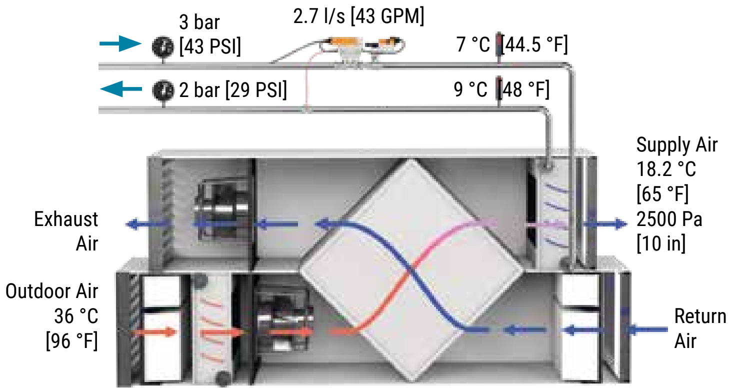


Figure 64: AHU without valve overflow

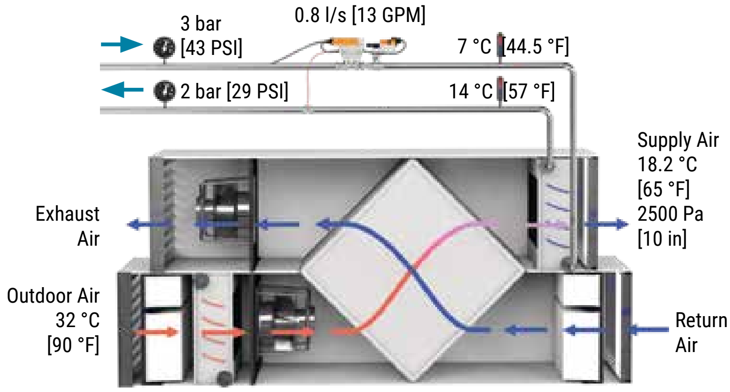


Figure 65: AHU with delta T-optimised valve flow

Pro Tip

The Energy Valve does not require the installation of circuit setters/regulating valves/commissioning stations, additional temperature sensors and flow meters – it is all in one product.

1.6 Success story

Belimo Energy Valves™ play an integral role in Land O'Lakes, Inc. corporate facility upgrade

Founded in 1921, Land O'Lakes, Inc. is one of America's premier member-owned cooperatives. It has 3,200 direct producer-members and 1,000 member-cooperatives, and together, they serve more than 300,000 agricultural producers in more than 60 countries worldwide.

Land O'Lakes, Inc.'s corporate headquarter consists of multiple buildings, of which, the two largest are a four-storey, 135,000 sq ft office building and a two-storey, 56,000 sq ft R&D facility/analytical research lab. Both buildings were constructed in 1980, and together they house roughly 1,100 employees.

The majority of the headquarter's chilled water needs are handled by a single, closed loop that is driven by a central chilling plant. The plant features two 300-ton centrifugal chillers (600 tons total). A total of six air handling units handle the cooling load for the headquarter – four in the office building and two in the R&D facility. When examining the operation of HVAC systems and equipment to identify where efficiency could be gained, Land O'Lakes, Inc. energy officials uncovered a costly issue in the AHUs' chilled water coils. Much of the time, delta T across the coils was lower than its design specifications. In addition to increasing electricity costs due to over pumping, this resulted in sub-optimal heat transfer and significant inefficiency at the building level. After conducting a thorough review of piping, valves and instrumentation, officials concluded that in order to solve the problem, various infrastructural improvements would have to be made. They then began the process of searching for a solution, which eventually led them to the Belimo Energy Valve™.

Figure 66: Office building, retrofit and energy savings of 15%

Customer Requirements: Save energy, improve occupant comfort and enhance operational visibility

The following objectives were formulated for the retrofit:

1. Increase delta T in chilled water coils to their design specifications and achieve energy savings through increased pumping efficiency.
2. Improve occupant comfort, particularly in the summer months.
3. Gain visibility into the operation of air handlers and chilled water coils. In recent years, the chilling plant had been unable to adequately cool the facility. Energy officials at Land O'Lakes, Inc. wanted to determine if that was due to insufficient chilling capacity or inefficiency at the building level.

The Solution: Belimo Energy Valve™

After various meetings with a Regional Application Consultant (RAC) of Belimo Americas, Land O'Lakes, Inc. made the decision to install Belimo Energy Valves™ on all six of the AHU's chilled water coils (AHU-1 through to AHU-6). The valves replaced the 3-way pneumatic valves that were installed when the facility was originally commissioned in 1980. The project also consisted of replacing all chilled water coils in the AHUs, as well as making improvements to piping and adding new motors and variable frequency drives (VFDs), to allow for more precise control of the chilled water loop. Two additional EVs were also installed on hot water coils that supply the R&D facility.

By installing the EVs and making various infrastructural improvements to buildings, Land O'Lakes, Inc. officials aimed to return water at, or near the design temperature of the chillers. In doing so, the amount of flow required to provide cooling to the building would be substantially reduced, and energy consumption at the central chilled water plant could be decreased. Officials also sought to utilise the diagnostic capabilities of the EVs to increase visibility into the operation of the cooling system, and more specifically, to determine the specific tonnage per air handler.

Results

Over the course of 31 days, the supply of chilled water through the EVs was monitored, and data was recorded in an effort to quantify their effect on the chilled water system.

To summarise, the data collected from the six Belimo Energy Valves included in this study indicate a potential flow saving of 6,210,964 gallons of pumped water over the time period, from June to August. Measurements also show that the valves had increased delta T closer to the design specifications of the chilled water plant, resulting in optimal heat transfer and more efficient chiller operation. In previous years, the lowest discharge air temperature that could be achieved at the facility was approximately 14.5 °C [58 °F]. After the Energy Valves were installed, discharge air temperature as low as 11 °C [52 °F] was observed.

Benefits

- Increased pumping efficiency and reduced energy consumption. Land O'Lakes, Inc. was able to achieve an average of 15 percent less kiloWatt usage in July and August.
- The electrical and mechanical contractor, NAC Mechanical and Electrical Services, was able to secure a rebate for the project. This rebate was based on the installation of the EVs, new VFDs, air handler coils, electric motors, and modifications made to necessary pipe and electrical infrastructure.
- Intelligent use of feedback data from Energy Valves to control pumps with VFDs allowed for more precise control of the chilled water loop, without sacrificing the AHUs call for cooling during occupied times.
- Diagnostic capabilities allowed for visibility into individual buildings and cooling coil performance, which helped make projections regarding future energy consumption.

Pro Tip

With the delta T scaling setting for the Delta T Manager, the designed flow, V'max, can be entered at the point 'DT flow saturation value'.

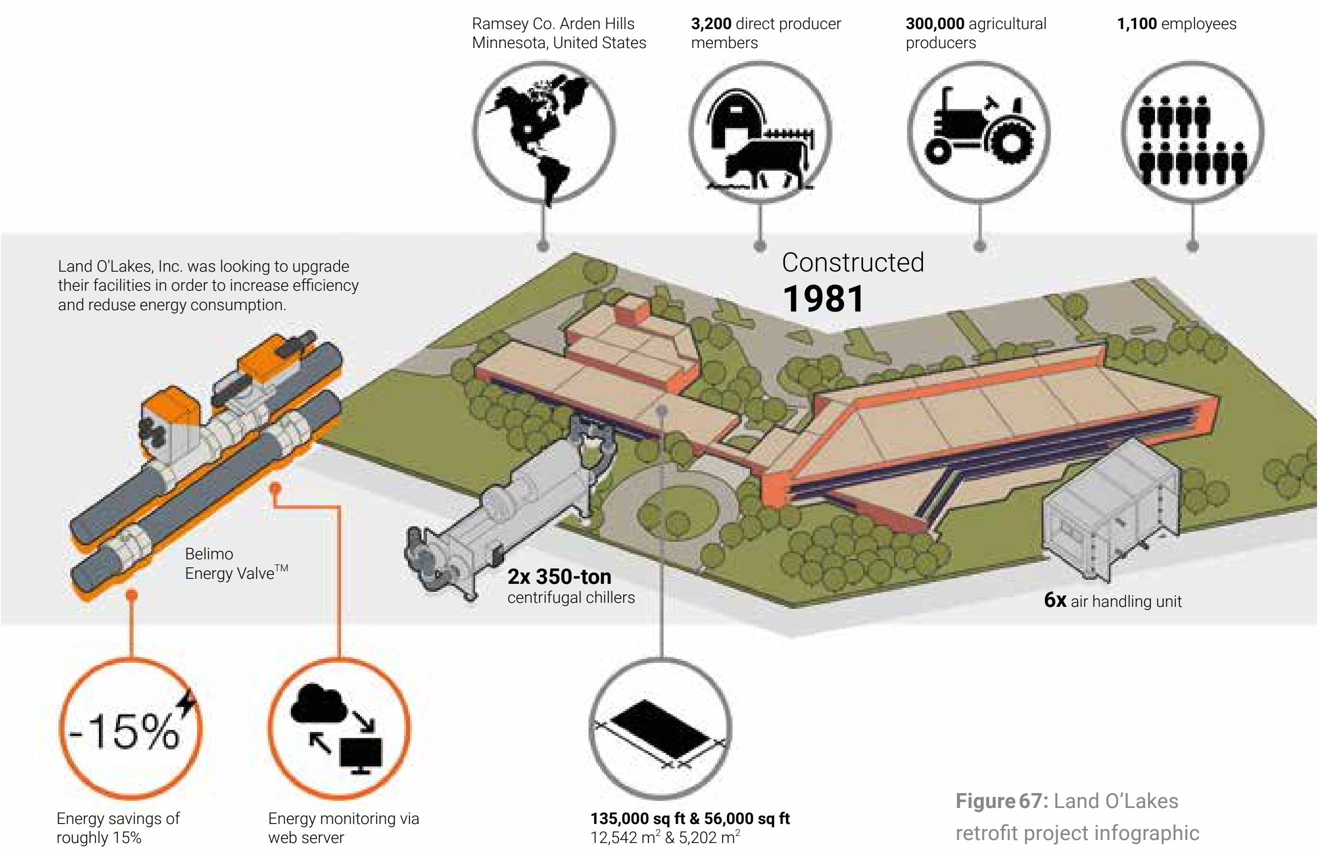


Figure 67: Land O'Lakes retrofit project infographic

2

District Heating or Cooling/Plate Heat Exchanger

2.1 Application description

Plate heat exchangers are often used to separate primary and secondary circuits in HVAC systems. Those circuits may have different medium or static pressure conditions. Flow can be direct current or counter current. Heat exchangers are extensively deployed in tall buildings to reduce the gravitational pressures provided by large water columns. Plate heat exchangers are also very common in district heating and cooling, or in load circuits, to heat potable hot water with a boiler.

Figure 68: Picture of a heat exchange station

2.2 Schematic

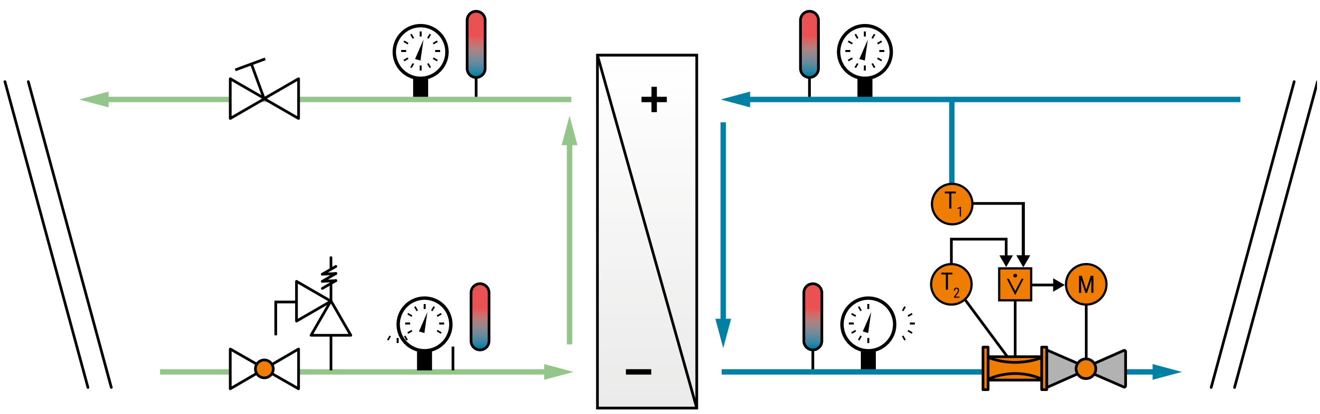


Figure 69: Supply side (green) and consumer side (blue)

2.3 Common issues in buildings, and how the Belimo Energy Valve™ addresses them

Problem: Incorrect direction of flow through heat exchangers
Sometimes flow directions through the heat exchangers have not been chosen correctly, as shown in figure 70. As a consequence, the heat transfer capacity is reduced.

Solution: Contraflow design
The two figures below show two possible flow installations, while the contraflow setup shows much better heat transfer. It results in larger delta T, and therefore higher energy efficiency, as shown in figure 72.

The Energy Valve is able to recognise false flow directions. If this is detected, an alarm flag will be sent to the BMS, and this can be discovered during commissioning.

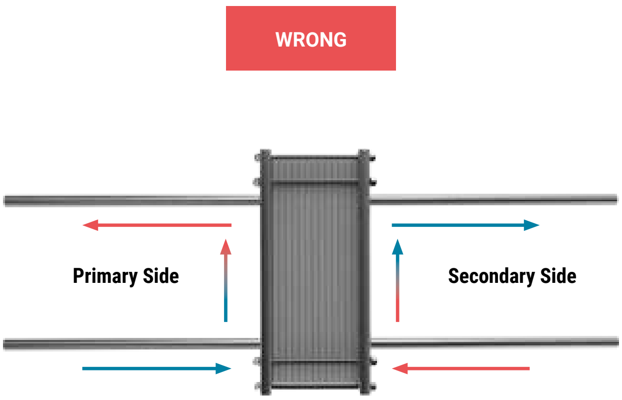


Figure 70: Cooling transfer station with direct flow

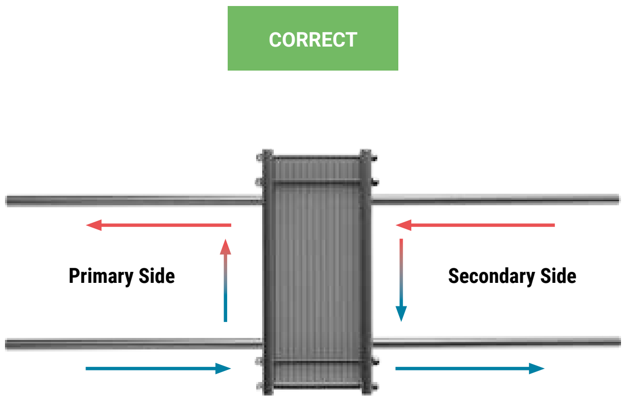


Figure 72: Cooling transfer station with contraflow

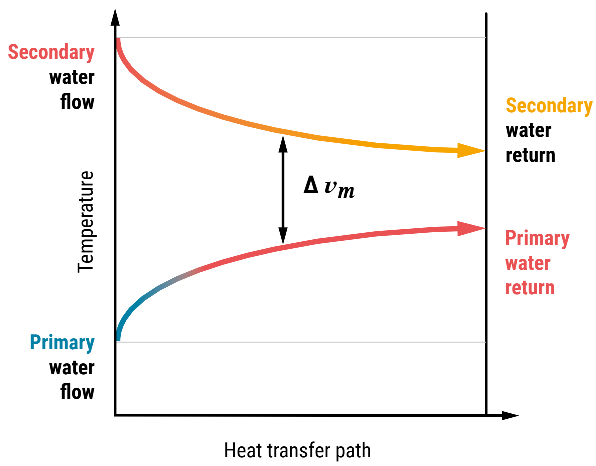


Figure 71: $\Delta\vartheta m$ average temperature difference with direct flow

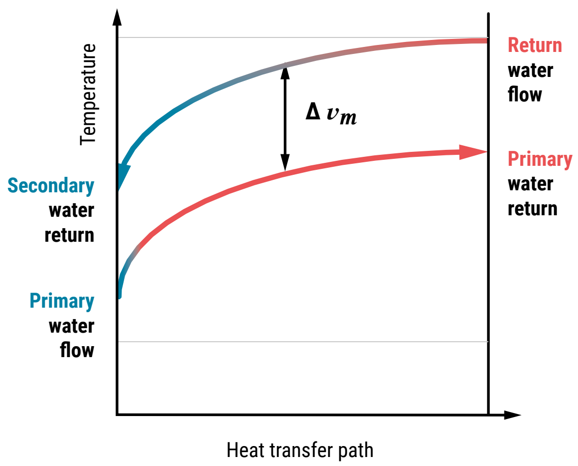


Figure 73: $\Delta\vartheta_m$ average temperature difference with contraflow

Typical Design Problem: Poor performance and low delta T syndrome
A traditional setup plate heat exchanger will have an energy meter and a traditional balancing valve controlling the maximum flow through the heat exchanger.

However, as figures 74 and 76 show, pressure fluctuations on the primary side cause the heat exchanger to overflow, resulting in low delta T and poor heat exchange performance.

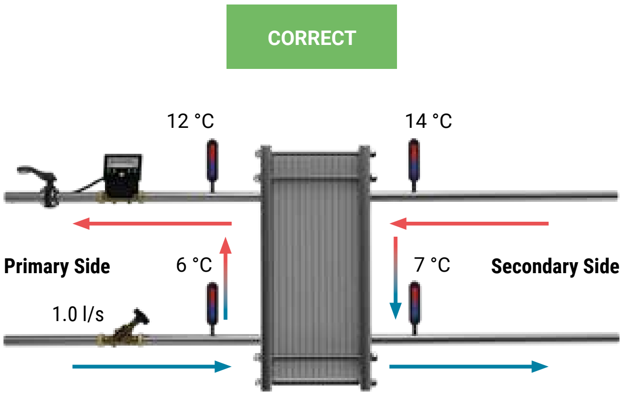


Figure 74: Typical design flow (cooling application)

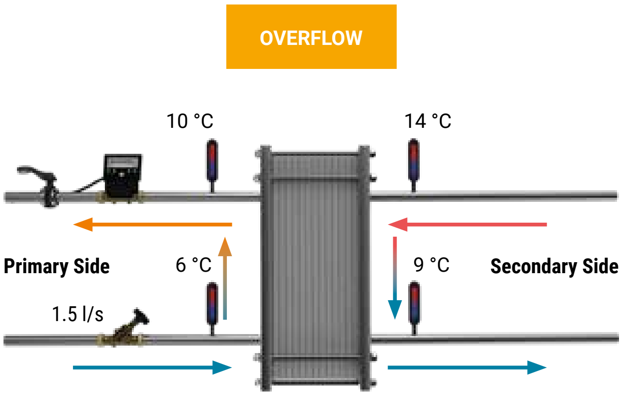


Figure 76: Overflow caused by pressure fluctuations

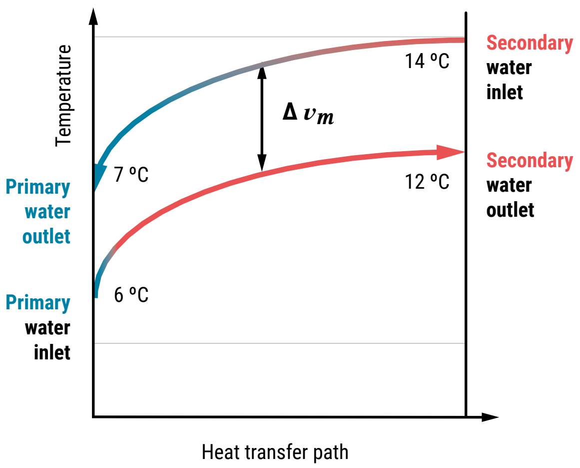


Figure 75: $\Delta\vartheta_m$ average temperature difference with design flow

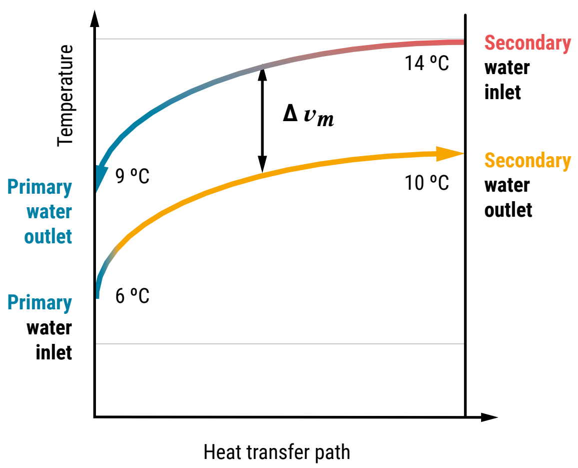


Figure 77: $\Delta\vartheta_m$ average temperature difference with overflow

Possible Solution: Dynamic balancing

By replacing the traditional balancing and control valve with a pressure independent valve, we solve the problem of pressure fluctuations across the system. This is a step forward, but still requires the application of multiple devices, including a separate thermal energy meter, as shown in figure 78.

Better Solution: Dynamic balancing with delta T monitoring

As shown in figure 79, with a single EV, we dynamically balance the system, monitor the energy usage for billing and record the delta T achieved.

This reduces the equipment needed to be installed, making installation simple.

Problem: Fouling and deteriorating delta T

Most heat exchangers suffer from fouling on one or both sides of the circuits. Minor fouling on one side can substantially affect the thermal energy transmission and drastically reduce the delta T.

Solution

The amount of time the Delta T Manager is active is indicative of the fouling process. If after a period of time the Delta T Manager remains active for extended periods, then the heat exchanger should be cleaned or replaced.

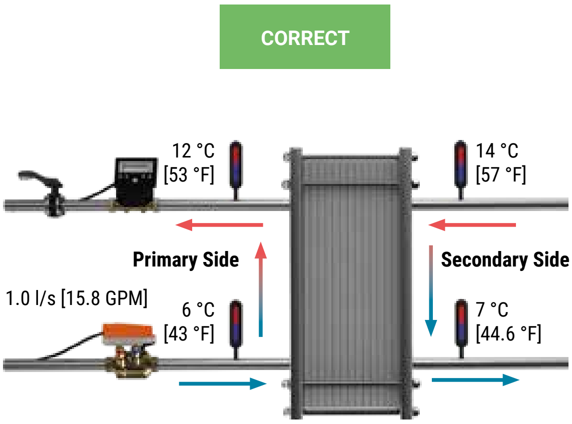


Figure 78: Dynamic balancing

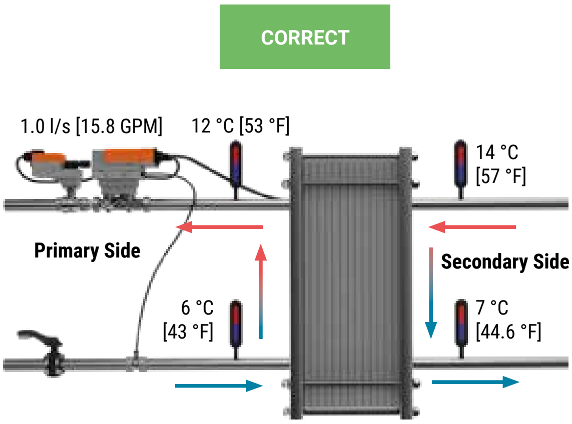


Figure 79: Dynamic balancing with delta T monitoring

Pro Tip 1

As heat exchangers tend to foul over time, it is a good practice to oversize the plate surface by a factor of two. Limiting the maximum power transmitted with power control will prevent overperformance of the heat exchanger. This installation will supply the correct power from the start, for a longer time, and will be very tolerant regarding ageing and prolonging maintenance intervals. Potable water boiler circuits with hard water can start building up scale in the heat exchanger, and thus reduce or block throughput over a time period of 3 to 4 years.

Pro Tip 2

Using the Belimo Cloud, you can remotely reduce power delivered by the Energy Valve should non-payment become an issue. The integration of EVs into a BMS or the Belimo Cloud can also be used for smart 'load shedding' to certain consumers or sections, and even allow the overall cooling capacity of a building to be temporarily reduced, eg. in periods of high electricity tariffs.

2.4 Success story

The Tennessee State Office Building reduced district energy chilled water usage by 49%, by applying the Belimo Energy Valve™

Founded in 1939, Jones Lang LaSalle (JLL) is one of the world's premier commercial real estate firms. The company is an industry leader in property and integrated facility management services, with a portfolio of 4.6 billion square feet [427.4 million square meters] worldwide.

Since its inception, JLL has been committed to delivering value to its occupants and stakeholders, by putting sustainability at the heart of its services and operations. In Nashville, Tennessee, an example of this commitment produced positive results as the company endeavored to improve energy efficiency and reduce chilled water usage at multiple buildings, by leveraging the advanced capabilities of the Belimo Energy Valve™.

Figure 80: Tennessee State Office Building

Facilities and project overview

Citizens Plaza stands in the heart of Downtown Nashville. The Class A, 275,000 square feet [25,550 square meters], 15-storey office building was constructed in 1984, and houses multiple Tennessee governmental agencies. During a typical workday, it has anywhere from 800 to 1,200 occupants.

Citizens Plaza receives its chilled water and steam from Metro Nashville District Energy System, which is located nearby on the Cumberland River. Chilled water from the plant enters the building at a temperature of 4.4 °C [40 °F]. As part of the contract, return water is to be no less than 12.5 °C [54.5 °F], or a delta T of 8.1 °C [14.5 °F]. Any water that leaves Citizens Plaza below the contracted delta T results in a thermal inefficiency charge. When JLL took over the management of building operations, the return water temperature was as low as 6.7 °C [44 °F], and this lingering problem needed a solution.

"At Citizens Plaza, we were experiencing high utility thermal inefficiency charges from Metro Nashville District Energy System due to low delta T and over pumping," said Chad Lovell, Operations and Safety Specialist at JLL. "We were pushing water too fast through the building and not getting sufficient thermal transfer. Initially, we saw poor delta T performance between 2.3° C to 4.5° C [4° F to 8° F]. Before JLL took over the contract, there were monthly thermal inefficiency charges of $12,000 to $13,000 for the building. It was obvious that we needed a strategy to increase delta T to reduce our chiller water usage."

The solution

To solve Citizens Plaza's low delta T syndrome and reduce thermal efficiency charges, JLL turned to Belimo.

"On our first visit to Citizens Plaza, we verified what we already knew, the structure was a Class A office building with air handlers on each floor," said Kevin Leathers, District Sales Manager at Belimo. "As is often the case in older buildings, the air handlers, globe valves, and coils were oversized. We had all the original drawings and realised pretty quickly that the Energy Valve was a perfect candidate for lowering chilled water usage, and optimising flow through the coils and air handlers."

After close communication between JLL and Belimo regional field consultants, Citizens Plaza underwent a pilot project installation with three 2-inch [DN50] Energy Valves, one each on the 2nd, 5th and 14th floors. The scope of work comprised a mechanical valve change-out without any control system modifications. The contractor removed the old globe valves and wired in the new Energy Valves with factory default settings. With these measures, the chilled water usage could be reduced by 49%, and the penalty charges from too low delta T could be eliminated.

3

Fan Coil Unit

3.1 Application description

A fan coil unit (FCU) heats or cools the air inside a space. A built-in fan draws the air into the FCU and through a heat exchanger for temperature conditioning. The air comes out of the FCU, either cooler or hotter than before. FCUs will generally have a chilled water coil for cooling, and either a hot water coil or an electric element for heating. In commercial applications, fan coil unit control varies dramatically, from a thermostat that simply opens and closes a valve, to DDC controlled units that infinitely vary air volumes and modulate valves.

Figure 81: Picture of a fan coil unit

3.2 Schematic

The figure below shows the schematic of a typical application in a room with two fan coils, each containing a Belimo Energy Valve™, managing the thermal power supplied to the fan coil. The use of EVs offers the following advantages:

- Dynamic hydraulic balancing (in any load condition) of the water flow, achieved by the pressure independent control valve
- Using the physical valve positions of the Energy Valves in a building, pump speeds can be optimised to provide just enough pressure to satisfy the index unit
- Full system transparency (volumetric flow, temperatures, cooling/heating output, etc.) with data recorded on the EV or, optionally, in the Belimo Cloud

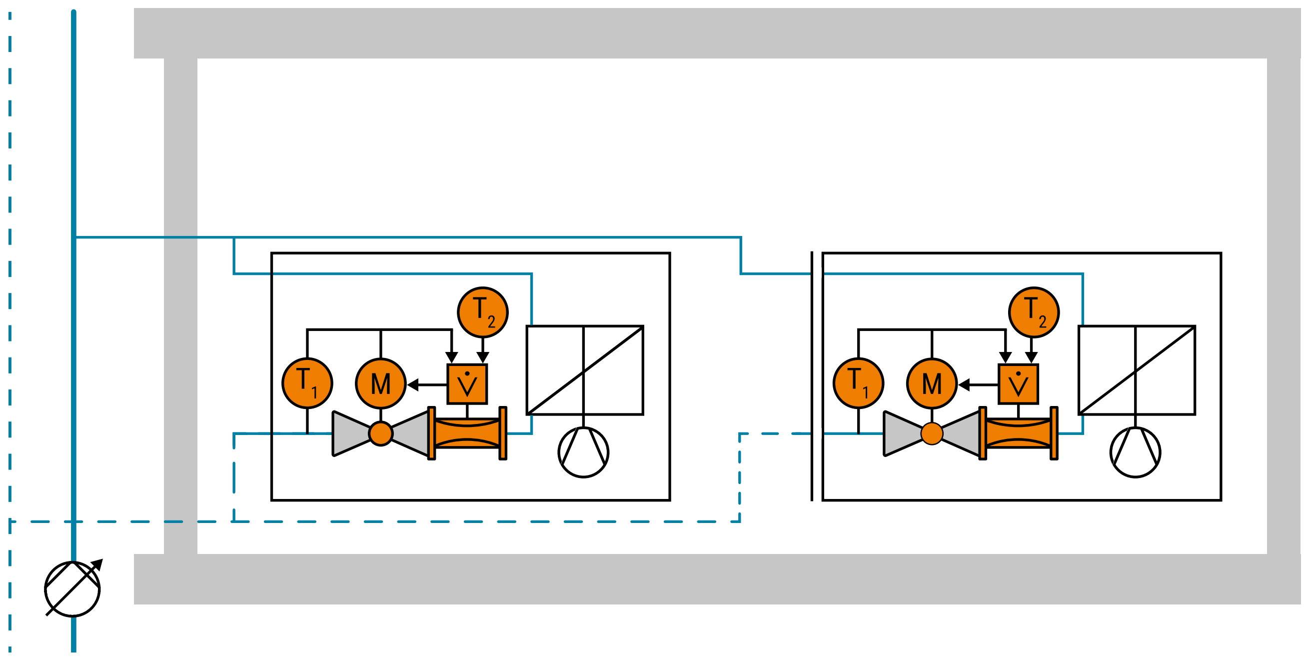


Figure 82: Typical fan coil application in a single room, with one EV per fan coil

3.3 Common issues with fan coils, and how the Belimo Energy Valve™ addresses them

Problem: Poor performance due to varying air flows and water pressure
For optimum heat exchange and occupant comfort while remaining energy-efficient, fan coils require good control of air volumes and water flow rates. However, manufacturers of FCUs often only publish flow requirements for maximum load conditions. What is unknown is the optimum water flow when air volumes are adjusted by the occupant or the DDC controller. Also, when using non-PI valves, differential pressure fluctuation in the hydronic system will impact the flow rate through the fan coil, and therefore the thermal energy supplied to the room.

Possible Solution: Dynamic balancing with mechanical PI valves
Reciprocal influence with several consumers is eliminated due to the dynamic balancing. Dynamic balancing is carried out automatically at each operating point. Changes in differential pressure cause minimal changes in the flow rate.

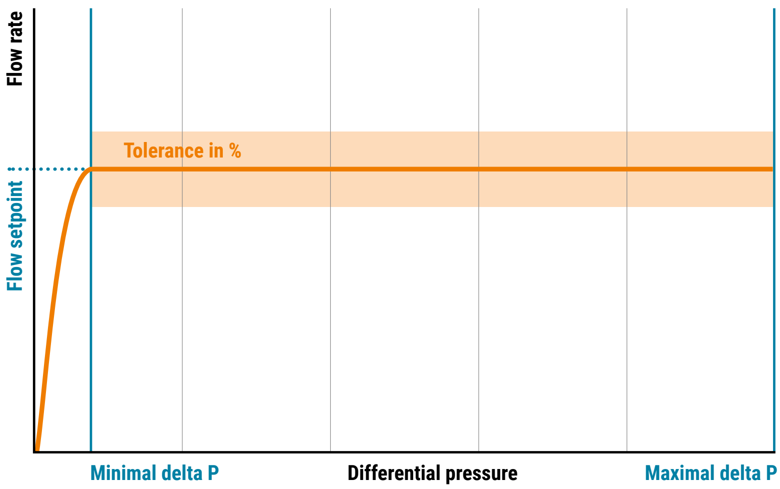


Figure 83: Dynamic balancing of a FCU

SPACE FOR NOTES

Typical Design Problem: Poor performance and low delta T syndrome

As shown in figure 84, a FCU is commissioned to the following values; design water flow is set to 0.11 l/s [1.74 GPM], with 23 °C [73.5 °F] air entering the unit.

As the system is dynamic after a short period of time, the pressure in the system increases due to changes in other locations of the hydronic system. In this specific FCU, the increase in pressure has caused the flow to increase, which results in overflow of the FCU, consequently lowering the delta T and lowering the efficiency of heat transfer.

As a result, an occupant of the space may have found the air flow bothersome and manually set the fan speed at low. As space temperatures rise, the valve is commanded further open by the controller until the air is simply unable to remove any more energy from the heat exchanger. This results in the return water temperature being cooler than expected.

With the water flowing too quickly for the air flow, we have a classic recipe for low delta T. This is effecting not only this unit, but is reducing the capacity of the central plant, and the overflow is significant at the point of consumption for the pumps with our flow now at 0.14 l/s [2.2 GPM], as shown in figure 85.

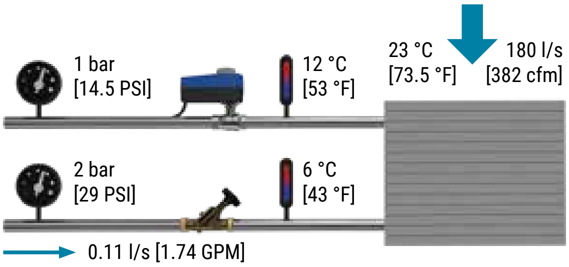


Figure 84: FCU at design operation

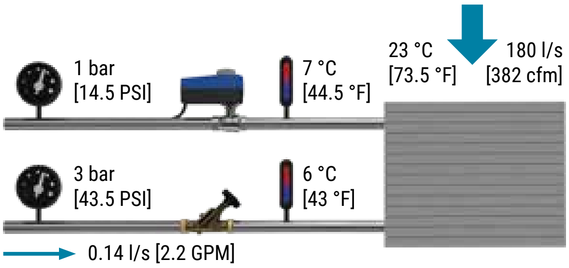


Figure 85: FCU with valve overflowing

Possible Solution: Mechanical dynamic balancing with PI valve

In figure 86, we have the same FCU working as expected; design water flow is set to 0.11 l/s +/- 10% [1.74 GPM], with 23 °C [73 °F] air entering. Even if the pressure rises from 2 to 3 bar, the flow rate hardly increases.

Flow rate inaccuracy is vastly improved and offers some plant savings, but not as accurate as an electronic valve. User fan speed adjustments still effect the optimum heat exchange, which will result in low delta T and poor off coil conditions.

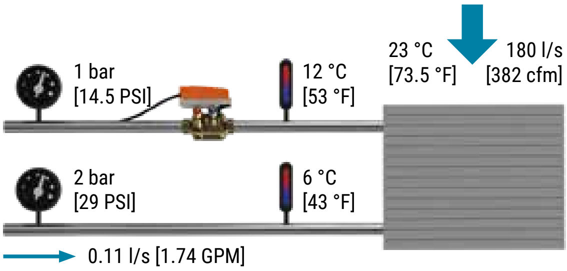


Figure 86: FCU at design operation

Better Solution: Dynamic balancing and Delta T Manager

Figure 87 shows the same FCU working as expected; design water flow is set to 0.11 l/s [1.74 GPM], with 23 °C [73 °F] air entering.

Again, the system delivers a pressure increase due to changes in other locations. The electronic flow sensor in the EV detects the flow increase before the room sensor can register an increase in space temperature. This allows the valve to close slightly to avoid reaching the saturation zone.

If the FCU has been held on low fan speed again, space temperatures rise. The valve is commanded further open by the controller, which would have resulted in the air being unable to remove any more energy from the heat exchanger. The EV's fixed Delta T Manager recognises the diminishing delta T and overrides the control signal DDC, and does not allow the valve to open further. This eliminates the overflow condition.

The EV continually measures the flow and calculates if it needs to compensate or not, based on the control signal DDC input, as well as on the Delta T Manager setpoint. The Delta T Manager has slowed the water down to ensure the heat exchange is optimal for the air volume set by the user, as seen in figure 88. This saves pump energy and keeps the system permanently optimised.

Energy Valve Solution: Dynamic balancing, power control and Delta T Manager

In the age of easily controlled EC/DC fans, variable air volume FCUs represent one of the most energy-efficient methods of air conditioning a space. However, the control of fan speed versus valve position is a matter of debate.

The Energy Valve, when configured for power control, provides a completely linear response, meaning that fan speeds can be directly tied to the valve output. This simplifies the controls process dramatically.

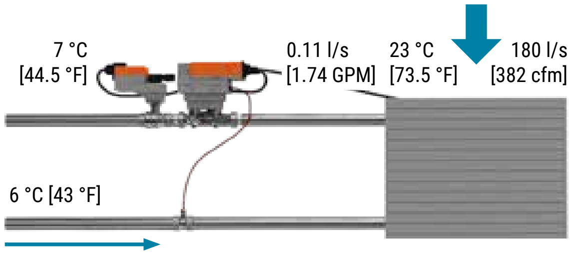


Figure 87: FCU without water overflow

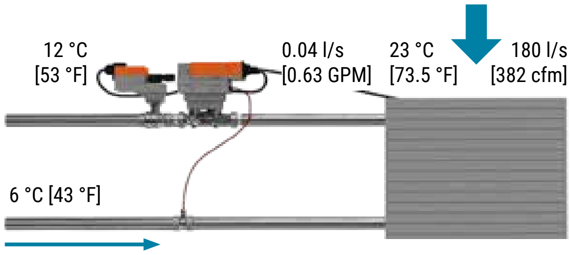


Figure 88: FCU with delta T-optimised valve flow

Pro Tip

Choose your fan coil setup carefully. It is recommended that fans draw air over a coil, rather than blowing through it, maximising the heat exchange. Contraflow coils maximise the possible heat exchange by reversing the flow of water against the direction of airflow, to reach highest possible delta T.

Figure 89: Marriott Hotel Al Jaddaf in Dubai

3.4 Success story

5 stars for energy efficiency at the Marriott Hotel Al Jaddaf in Dubai
The Marriott Hotel chain opened its facility in Dubai, UAE, on 15th January 2014. With its brilliant design and perfect location in Al Jaddaf, this 5-star hotel has an abundance of thoughtful amenities. These include fully automated luxury guest rooms and suite accommodation that encourages relaxation, with luxury bedding, marble bathrooms, high-speed Internet and flat-screen TVs, while also providing views of the Dubai skyline. The hotel offers 352 luxury guest rooms and 128 hotel apartments. The Belimo products could be implemented efficiently to enable a sustainable and maintenance-free system.

Initial situation
The 5-star Marriott Hotel has been equipped with pressure independent characterised control valves and modulating actuators for all the fan coil units serving the guest rooms. Electronic pressure independent valves (ePIVs) have been installed for the air handling units serving the kitchen and common areas. The Belimo Energy Valves™ have been used for the heat exchangers serving the swimming pool and for maintaining a constant delta T. The BMS contractor, Johnson Controls, has done the master integration of the units to the BMS using the Metasys Platform, thus providing easy control for the Facilities Managers and their team in the Marriott.

Project requirements

- The project schedule was critical
- The customer was looking for the pressure independent valve technology to eliminate over and under sizing, and to ensure smart control and efficiency
- The products used should not require any maintenance or re-calibrations
- Flexibility to adapt on site to the true system conditions

Belimo solution

The 1,100 pieces of Belimo valves have been specified by the Consultant Arif & Bintoak Consulting Engineers to include pressure independent characterized control valves (PICCV), electronic pressure independent valves (EPIV) and Belimo Energy Valves™. All PICCVs were pre-calibrated. These valves are capable of controlling a complex cooling system throughout the building, comprising of 10,000 gallons of water. The time savings inherent in the ePIVs and Belimo Energy Valves™ solution provide significant value over alternative approaches. The time taken for the system to be commissioned was crucial for the installers, who under contractual obligations would have been penalised for delays. By using the Belimo Energy Valve™, the system is not only energy-efficient through the recording of all data, but also an optimisation potential is given for the facility management. With the Belimo electronic pressure independent valve (ePIV), it is easy to adjust the maximum flow rate, and thanks to 'air bubble tight', closing characterised control valve, no leakages are possible. With the Belimo valves, it is possible to control the system with installation-friendly, versatile, transparent and secure products.

Figure 90: The supply of the fan coil units is equipped with the Belimo Energy Valve™

Customer benefit

- Belimo Energy Valve™ ensures the regulation of flow and heat exchanger power output, and monitors the delta T value
- Easy selection without calculation
- Significantly reduced operating costs from the beginning of the project and throughout the entire life of the system
- Easy integration of the measuring and controlling function in one device
- Engineers avoid complex sizing at the design stage, and gain greater peace of mind that the system will operate correctly from the beginning
- The Facilities Managers are able to control the hotel efficiently from the BMS dashboard
- The Belimo flow and power control algorithms control more accurately, significantly reducing actuator movement

4

Chilled Beam

4.1 Application description

A chilled beam is a type of convection HVAC system designed to heat and cool spaces, typically deployed in open plan office buildings. Tubes are passed through a 'beam' (a heat exchanger), either directly integrated into a suspended ceiling, or hanging below the suspended ceiling of a room. There are two types of chilled beams in use today. A passive beam chills the air around it, forming a natural convection current where cooled air falls and warmer air rises to replace it, therefore cooling the space. Active chilled beams are widely used as well, and use air from an AHU to induce additional airflow over the beam.

The principal challenge with this application is the control of the water temperature and flow rate, assuring that the surface temperature of the beam doesn't fall below the dew point of the space.

Figure 91: Ceiling-integrated chilled beam with air and chilled water supply

4.2 Schematic

Figure 92 shows the schematic of a chilled beam application using an Energy Valve. This provides the following control functionality:

- Accurate measurement of volumetric flow and the supply and return temperature
- Monitoring and control of thermal power of the unit
- Permanent hydronic balancing of the water flow at changing system pressures and in any load condition
- Optional integration of a dew point sensor switch
- Required delta T on chilled beams is very low, making managing them, critical

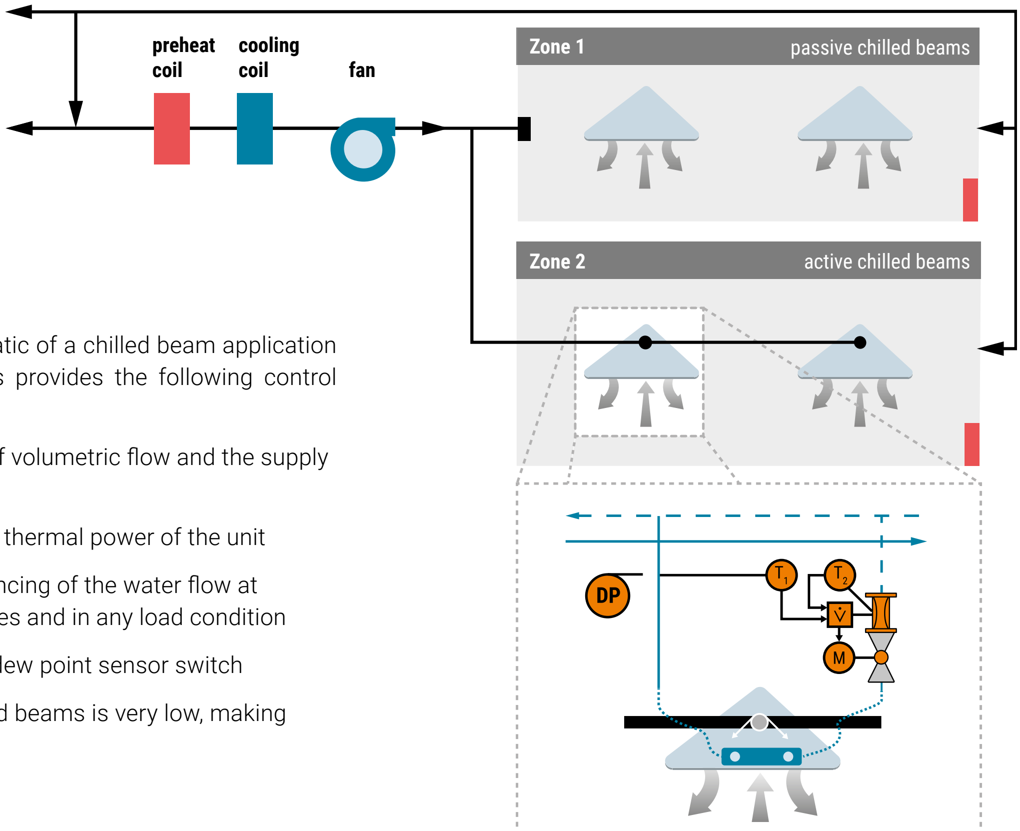


Figure 92: Chilled beams applied in a multi-zone setup

4.3 Common issues in chilled beam applications, and how the Belimo Energy Valve™ addresses them

Problem: Pressure fluctuations affecting flow rates and comfort
Large chilled water systems are dynamic in nature, with pressure fluctuations caused by pump speed and valve position changes. Statically balanced systems, as the name suggests, are unable to deal with these dynamic changes and, as a result, flow rates through each unit fluctuates with pressure changes.

Possible solution: Dynamic balancing
The dynamic balancing function of a pressure independent valve handles pressure fluctuations in the system, and assures that the flow is maintained on the defined setpoint.

Problem: Condensate forming on the chilled beam
Low water temperatures and insufficient humidity control can lead to condensate forming on the chilled beam, and can subsequently damage furniture of office equipment that can be costly. However, conservative supply water temperatures can result in insufficient cooling capacity.

Solution: Early detection of low flow temperatures with the Belimo Energy Valve™
Using the more accurate and responsive immersion flow sensor from the Belimo Energy Valve™, DDC systems are able to detect and close-off water flows before condensate forms on the chilled beams.

Reliable data from both the space and the water temperatures is the key to maximising chilled beam performance, while minimising the risk of condensate forming.

An outdoor humidity/temperature sensor, such as the Belimo 22UTH-11, can be used to measure the outdoor air conditions and to adapt the AHU-control accordingly.

Figure 94: Belimo 22UTH-11 outdoor humidity/temperature sensor with weather shield

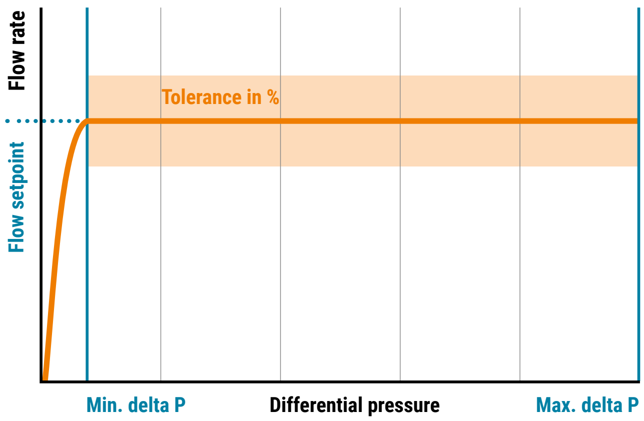


Figure 93: Dynamic balancing of a chilled beam

Figure 95: Condensation of humid air on the cold coil surface. The supplied cooling water needs to be above the indoor dew point to prevent condensation

Supply air into the occupied space, and the circulated air from the room, pass over the coils of the chilled beam. The indoor dew point must be maintained below the surface temperature of the chilled beam coil to prevent condensation water dropping from the ceiling.

The primary air system in the AHU is used to offset the space latent load, and it typically maintains the indoor dew point at or below 13 °C [55 °F] to prevent condensation.

Also, the water temperature delivered to the beams is typically maintained between 14 °C [58 °F] and 16 °C [60 °F], sufficiently above the dew point of the space.

Pro Tip

Consult local standards on recommended room air temperatures and humidity values (or maximum values), as well as recommended cooling water temperatures

If you have smaller cooling loads in the room or large cooling surfaces, the cooling water temperatures can be raised by a few degrees (for example, up to 18 °C). It should still be possible to maintain sufficient cooling in the room, and thus dehumidification can be carried out in an energy saving way.

To prevent condensation on the chilled beam in the room, the humidity of the air supplied to the units, and/or the temperature of the cooling water must be adjusted to the dew point in the room.

The cold water supply pipe must be insulated, vapour diffusion tight. A condensate sensor is installed on a short, uninsulated pipe section in front of the unit. The supply water temperature is controlled using this sensor.

If condensation is detected, two control strategies are possible:

1. The branch water supply temperature is raised, leading to a variable supply temperature to avoid condensation. As a negative side effect, the possible cooling effect of all subsequent chilled beams is reduced, but water flow is still allowed at design level.
2. The branch water supply flow is reduced with the control valve of each subsequent chilled beam. Depending on the floor and piping layout, a central dew point sensor per unit may be required.

Figure 96: Belimo 22HH-100X condensation detector

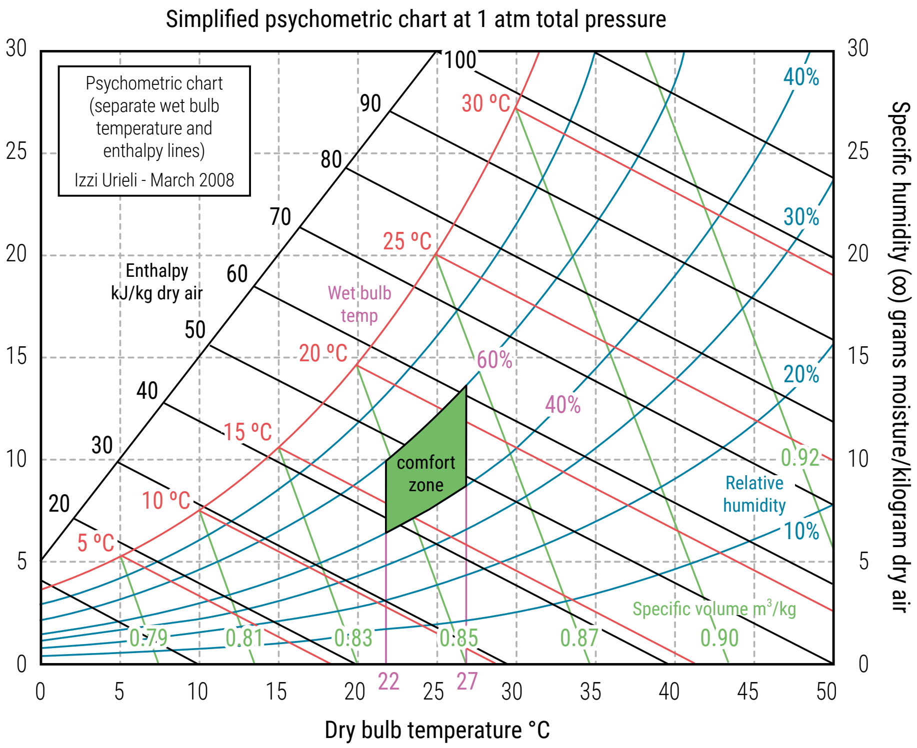


Figure 97: The dew point depends on the air temperature and humidity

4.4 Application example

Typical Design: Poor performance due to overflow
In figure 98, a Chilled Beam is not working as expected. Design water flow should be 0.12 l/s [1.9 GPM], with delta T at 3 °C [1.5 °F], and a differential pressure across the loop of 1 bar [14.5 PSI]. However, due to the pressure changes in the system, delta P increases from 1 to 2 bar [14.5 to 29 PSI], and different loads are needed. The chilled beam is receiving 25% more water than design. This results in poor comfort in the ambient and lowers the efficiency of the heat transfer.

PI Valve: Dynamic balancing to avoid overflow
As shown in figure 99, using the mechanical pressure independent valve, PIQCV, guarantees the design flow 0.12 l/s [1.9 GPM], even when pressure fluctuations happen in the system. This results in better control and comfort.

Energy Valve: Dynamic balancing, Delta T Manager and data transparency
The Energy Valve will keep the flow as designed regardless of pressure fluctuations, at 0.12 l/s [1.9 GPM], as shown in figure 101. It will also manage the delta T over the coil and provide all essential data regarding flow, temperatures and energy to the BMS.

Using the data available from the EV, many other value-added features are available, such as early detection of likely condensate issues.

As shown in figure 101, the Energy Valve is on the same network as the sensor and the BMS head-end PC. The BMS is looking at the water flow temperature and calculating the dew point, using the RH and temperature data from the room unit.

The BMS has seen the entering water temperature is at dew point, and has commanded the valve to close, in order to prevent condensate forming on the unit.

The Delta T manager will keep your beams optimised when air flows over the coil vary.

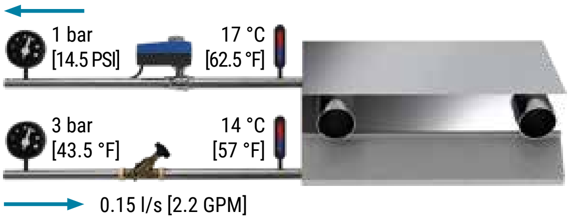


Figure 98: Chilled beam with a pressure dependent valve

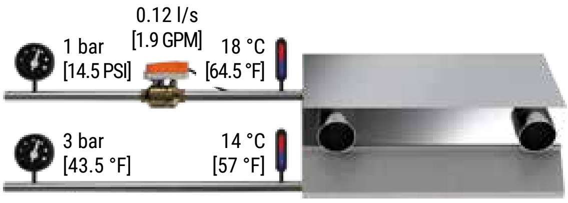


Figure 99: Chilled beam using a mechanical PI valve

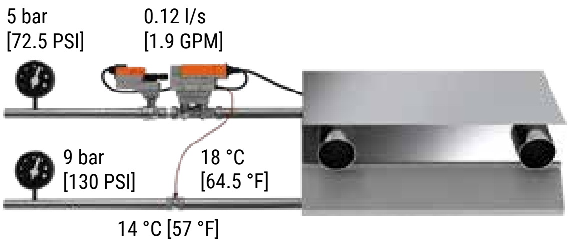


Figure 100: Chilled beam using an Energy Valve

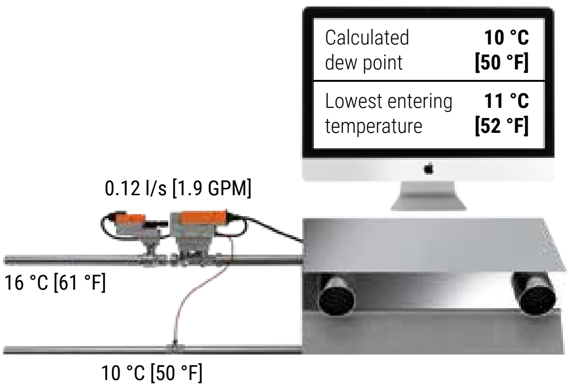


Figure 101: Chilled beam using an Energy Valve, with the BMS calculating the dew point with the input from a room sensor

5

Two Pipe Change Over

5.1 Application description

Two pipe change over (TPCO) systems are typically used where it is too expensive to run dual sets of pipe work to each consumer, or it is expected that there will be a low number of days the units actually spend heating. With a single set of pipes, the unit can only heat or cool at one time.

Ordinarily, it is expected for the space to have some form of backup heating (typically electric elements), to use when the system is in cooling and only when a few zones require heating.

TPCO systems are usable for:

- Fan coil units
- Chilled beams
- Chilled ceilings
- Floor heating (mostly in residential buildings)

Pro Tip

Choosing the right valves for the change between heating and cooling is important. Globe style valves often have a leakage or passing rate, ie. an amount the valve will let past even when it is closed. This will cause hot water to leach into the cold or vice versa; either way you are loosing energy.

5.2 Schematic

Figure 101 shows a condensed setup with a single terminal unit. However, applying EVs instead of standard control valves uniquely allows designers to use the less costly two pipe design, while still achieving the same comfort associated with four pipe systems. Energy Valves can be updated with different flow and delta T setpoints for cooling and heating, in effect, the BMS is able to make the same valve act like two different valves.

Problem: Pressure fluctuations affecting flow rates and comfort
Large chilled water systems are dynamic in nature, with pressure fluctuations caused by pump speed and valve position changes. Statically balanced systems, as the name suggests, are unable to deal with these dynamic changes and, as a result, flow rates through each unit fluctuates with pressure changes.

Possible Solution: Dynamic balancing
The dynamic balancing function of a pressure independent valve handles pressure fluctuations in the system, and assures that the flow is maintained on the defined setpoint.

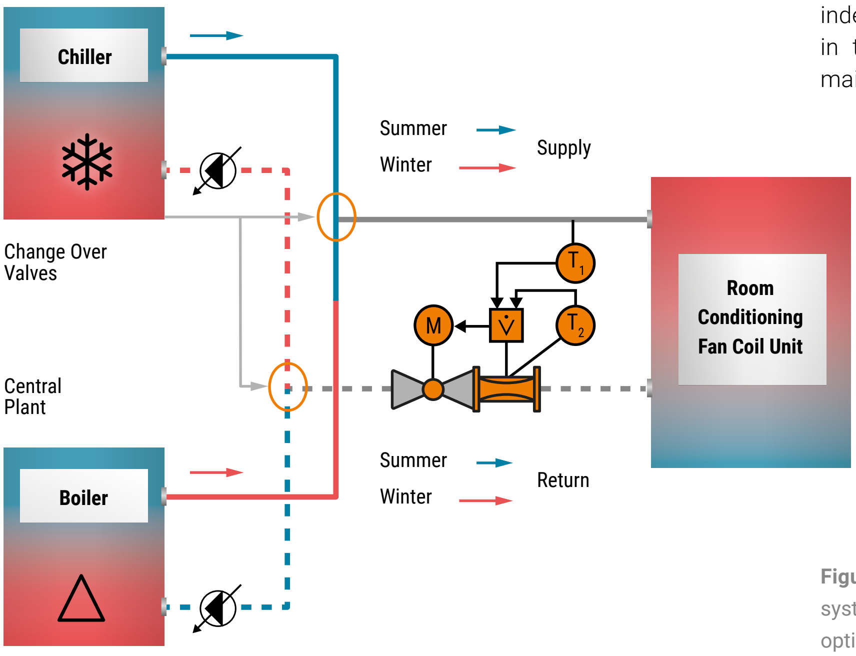


Figure 102: Two pipe change over system using an Energy Valve for optimal comfort in summer and winter

5.3 Common issues in two pipe change over systems, and how the Belimo Energy Valve™ addresses them

Problem: Poor performance in heating mode
Heat exchangers or coils are typically selected on cooling loads, meaning that if the water medium is simply switched from cold to warm, the design flow rates are no longer suitable. For example, a typical cooling delta T would be 7 K, while you would expect a heating delta T of at least twice that.

Solution: Adjustable flow rates for heating/cooling season
As an intelligent valve is capable of high level communication with the BMS, flow rates can be updated remotely. This allows a change in design flow rates to be applied so that the valve is always controlling to the optimum flow rate.

Problem: Low delta T syndrome
As the heat exchanger is not only experiencing a change in water temperature, it could be experiencing a change in air volume in line with the new mode. With multiple variables of the heat exchange fluctuating, it now becomes virtually impossible to completely predict the correct flow rate over the range of permitted flows.

Solution: Energy Valve using the Delta T Manager
The Delta T Manager, integrated in the Belimo Energy Valve™, is a function that continuously measures the temperature spread and compares it with the system-specific limiting value. If it falls below this, the Belimo Energy Valve™ automatically adjusts the flow so that only the amount of water actually needed is allowed through the heat exchanger. It is possible to update the required delta T using the bus interface, as easily as the water flows, giving you complete control.

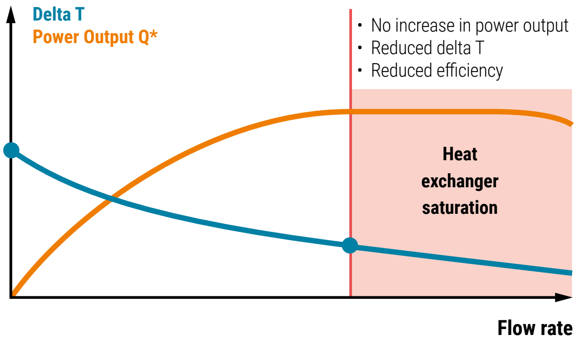


Figure 103: Low delta T at a consumer (eg. two pipe fan coil)

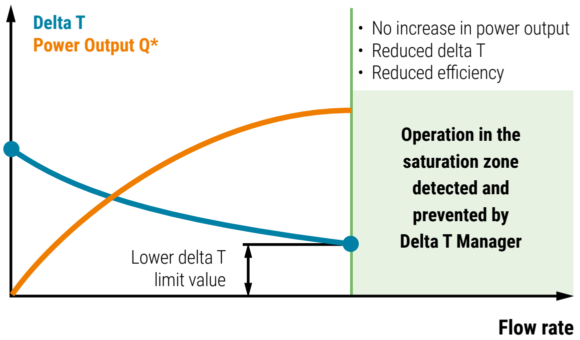


Figure 104: The Delta T Manager of the EV assures minimal delta T

5.4 Application example

Typical Design: Poor performance and low delta T syndrome

The example shown in figure 105 depicts a traditional setup with a flow rate of 0.11 l/s [1.74 GPM], based on the required cooling power, given inlet temperatures 6 °C [43 °F] and outlet temperature 12 °C [54 °F]. The heating flow rate required for the space is 0.05 l/s [0.79 GPM]. However, the system is set to deliver 0.11 l/s [1.74 GPM]. As a result, the heating performance is largely on/off.

This works to a degree, but the poor delta T experienced during the heating phase typically makes this setup incompatible with condensing boilers, because the return temperatures are too high for them to condense. As the heat exchanger is given the same flow rate of 0.11 l/s [1.74 GPM] when heating, the water is unable to give up sufficient energy to air, resulting in high return water temperatures or low delta T, as shown in figure 106.

As there are no PI valves fitted to this solution, we still suffer with all the cross pressure fluctuations typically seen with non-PI valve setups. This worsens the delta T further.

Solution: Dynamic balancing, change overflow and delta T control

As shown in figure 108 and 109, the BMS can decide which type of day it is, and update the Energy Valves with the required heating or cooling flow for the corresponding delta T.

Using the EV, both the design flow can be set and delta T can still be assured during a pressure fluctuations.

With the Energy Valve being updated with heating flow rates and delta T, the valve switches to 0.05 l/s [0.79 GPM] and enforces a minimum delta T of 30 K. Doing so, now allows the use of condensing boilers on the project, as the return water temperatures can be assured.

Pro Tip

The Energy Valve will also record the usage of heating and cooling energy separately, so instead of buying two meters, one for heating and one for cooling, now you only need one device!

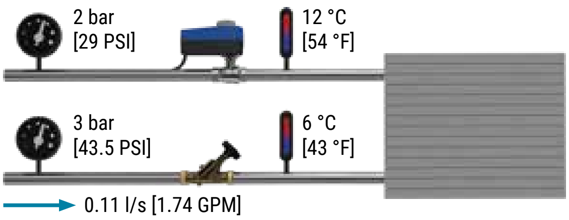


Figure 105: FCU in cooling condition

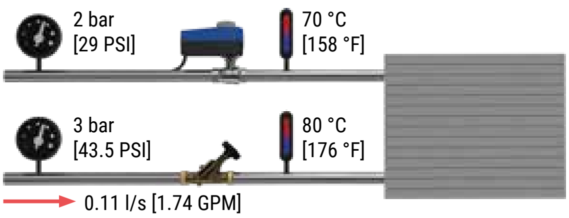


Figure 106: FCU in heating condition

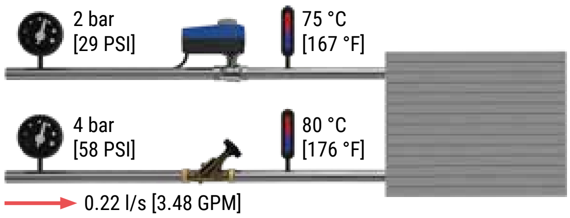


Figure 107: FCU heating conditions and pressure increase

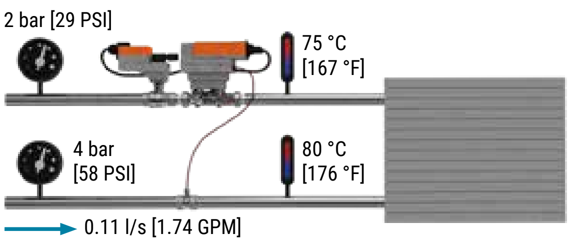


Figure 108: FCU in cooling mode, using a pressure independent EV

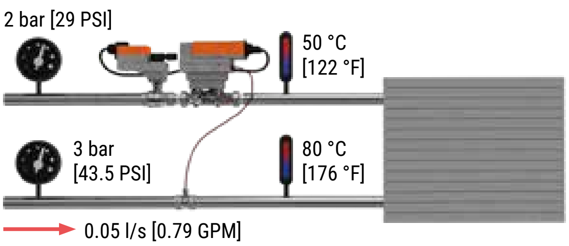


Figure 109: FCU, with BMS corrected heating setpoint and required flow

6

Branch Flow and Delta T Control

6.1 Application description

Large distributed systems, either as a building or part of a larger district system, need good delta T to operate effectively. Application of the Energy Valve on every unit might not always be practical, and installation of the Energy Valves on the main risers or entry to the building for district cooling isn't advisable, as Delta T Manager may starve individual units while trying to manage a whole building.

Figure 110: A high-rise building fed from a district cooling plant that would benefit from this application

6.2 Schematic

The system shown in figure 111, using Belimo Energy Valves™, provides the following advantageous functions:

- The flow to the branch is monitored, and can be set to prevent overflow to the floor and also monitor the delta T
- Energy on to each branch is monitored. This can be logged and alarmed if demand from any one branch increases dramatically
- Flow through each terminal unit can now be verified using the flow meter attached to the Energy Valve, by opening them one at a time. Closing all valves will confirm if the valves are allowing water past when closed, or if a bypass valve is open
- Full branch transparency (volumetric flow, temperatures, cooling/heating output, etc.) with data recording and Belimo Cloud connection

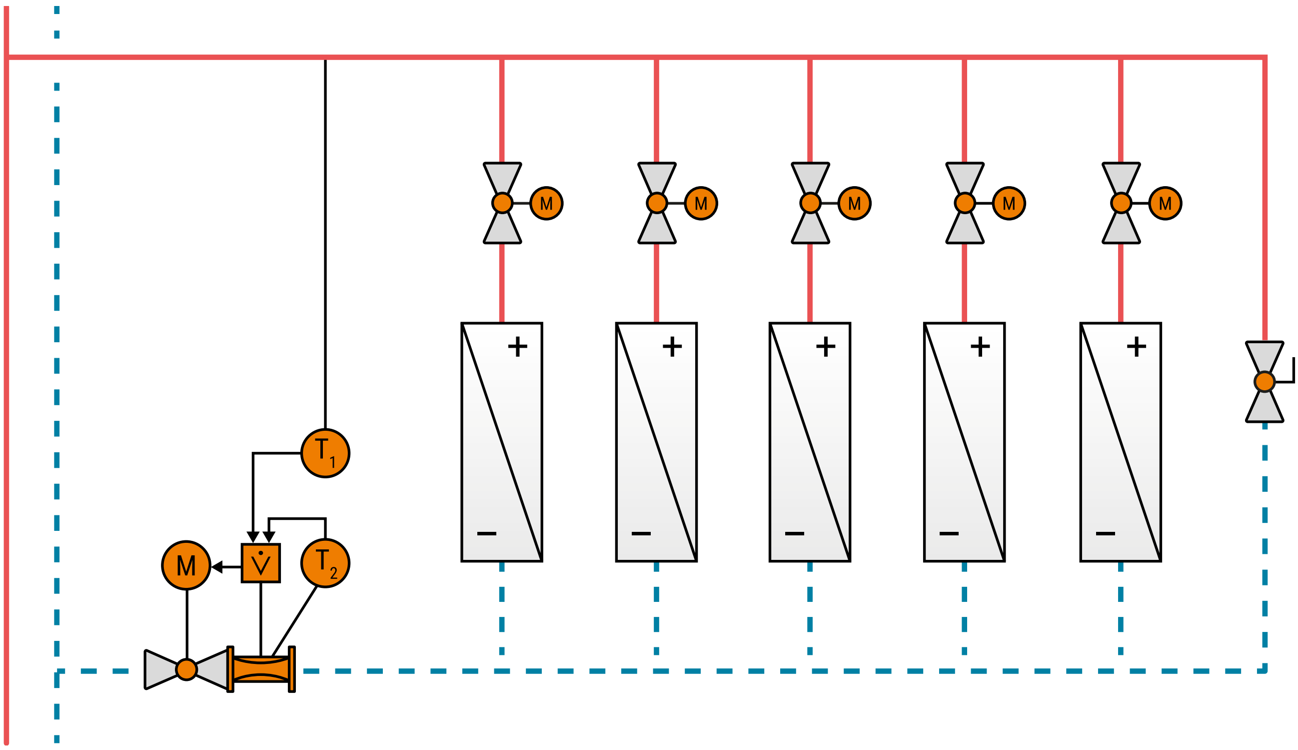


Figure 111: A schematic showing the installation of an Energy Valve in a branch application

6.3 Common issues in terminal unit branches

Problem in existing buildings
Larger buildings have complex distribution systems and are occupied, meaning that the retrofit of an Energy Valve on each terminal is impractical.

However, lack of capacity at peak times or fines from district plant providers often drive building owners to look for a solution.

Figure 112 shows a pressure dependent system with a single balancing valve. This is a typical contract installation of multiple low flow heating units, for example, used for underfloor heating.

Solution: Retrofit with Belimo valves
This can be remedied by retrofitting Belimo Energy Valves™ to every branch. Monitoring the flow and delta T being supplied to a number of terminal units allows facilities teams to identify problem 'passing units' and bypasses left open.

This focus improves efficiency quickly by offering a targeted approach to overcoming the issues being experienced.

This involves replacing passing or stuck terminal valves with 'air bubble tight' zone valves, or closing a bypass valve that has been inadvertently left open.

Problem: Poor unknown flow rates from mechanical valves
Our need to operate more efficient buildings, drives the demand to check water flow rates not just once but multiple times during each season. Experience tells us tenant fit outs or changes to hydronic system adversely effect non-PI installations.

However, even with PI valves installed, checking the identifying passing valves and open bypasses should remain a priority to keep delta T to an acceptable range.

Solution: Multiple flow dynamic measurements
By using an EV in the branch line, we are able to measure the total flow to the floor and also to each individual unit, if opened sequentially. This is shown in figure 113.

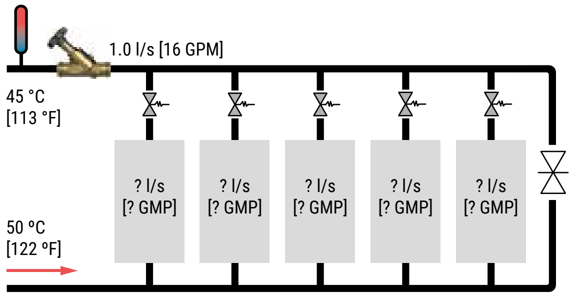


Figure 112: Mechanical balancing valves only allow for a static balancing of the total flow to the floor, with unknown flow rates to each individual unit

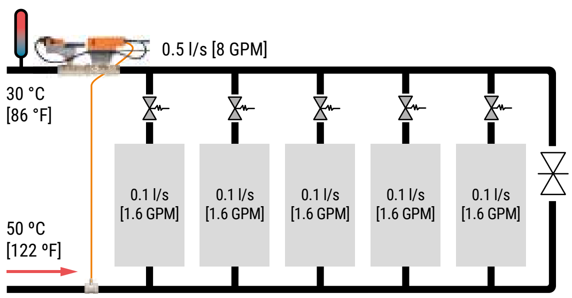


Figure 113: With an EV, the branch flow can be measured when each valve is opened, allowing for verification

Problem: Ghost energy in building
Ghost energy/passing/leakage is typically used to describe the process where water is unintentionally passing from the flow side to the return. As shown in figure 114, a bypass is left open after maintenance or at axial valve leakage rates. These small rates quickly add up when a large number of them are applied. The rate at which these valves pass or leak is made worse over time by the accumulation of dirt on the seats of the valves.

Solution: Multiple flow dynamic measurements
By using an EV in the branch line, we are able to measure the total flow to the floor and to each individual unit. You can ensure bypasses are closed and valves are not leaking. Should a number of terminal valves suffer from leakage, the characterised ball valve technology in the EV can be closed, hence providing a stop to the wastage when the branch is not in use.

Problem: Low delta T syndrome
Often, terminal units are statically balanced, which leads them to overflow and deliver low delta T when in part load. Valves may be allowing water past them when they should be closed. Sometimes, even a bypass left open can stay undetected, reducing the pressure and dragging the delta T down.

Solution
The Delta T Manager, integrated in the Belimo Energy Valve™, is a function that continuously measures the temperature spread. This information can either be used to raise an alarm while you are troubleshooting the branch, looking for passing/leaking valves or bypasses left open. Once the branch is performing as well as it can, you can enable Delta T Manager to limit overflows to the branch.

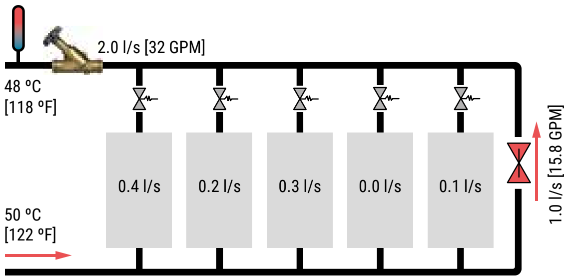


Figure 114: An accidentally open bypass valve may not be discovered for weeks, months or even years

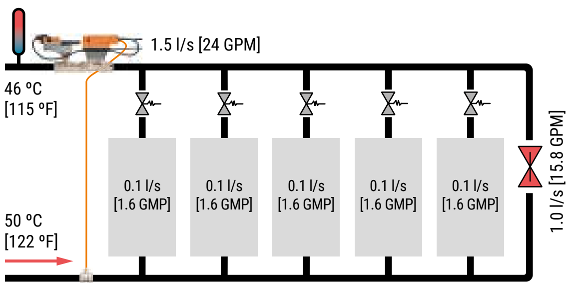


Figure 115: With an EV, both leaking short-stroke valves or an open bypass can be clearly identified

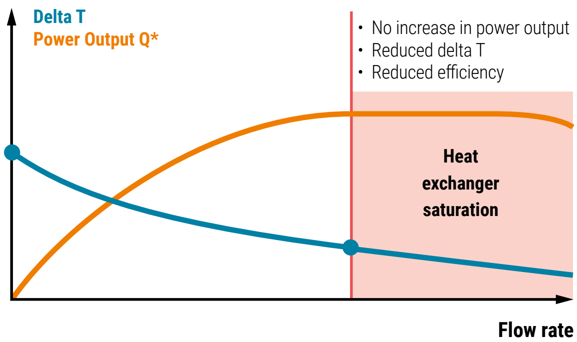


Figure 116: Low delta T syndrome

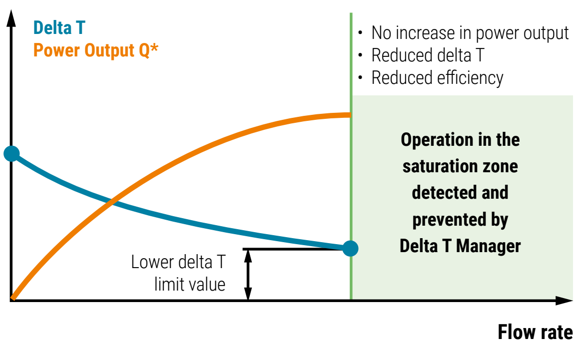


Figure 117: Delta T Manager

6.4 New buildings

Typical Design: Leakage, difficult to witness flows, and no checks for ghost energy wastage
As shown in figure 118, using our traditional setup, we set the flow rate on each coil using a balancing valve.

As there are no PI valves fitted to this solution, we still suffer with all the cross pressure fluctuations typically seen with non-PI valve setups.

Possible Solution: Dynamic balancing
A simple upgrade to PI valves improves the balance of the system, but if flow verification is required, access is still needed. This often involves working at height, as shown in figure 119.

All mechanical PI valves including the Belimo PIQCV are affected by hysteresis, the phenomenon where a spring does not return to the same place. This makes repeating the same flow values difficult from these devices, particularly when you have a low commissioning tolerance of 0%/+10%.

Optimal Solution: Dynamic balancing, remote verification, branch monitoring of energy consumption, ghost energy and leakage
As shown in figure 120, mechanical PI valves take care of the dynamic balancing, and the Energy Valve is now introduced on the return line, as a monitor. This offers the following advantages:

Remote verification
Each valve on the branch is opened in turn to the design preset limit via the BMS. The flow rate for the only open valve would be visible via the BMS through the flow rate point.

Branch monitoring
By continually monitoring the flow and delta T, the Energy Valve is able report the energy consumed by the branch.

Ghost energy and leakage
The valve can be alarmed by the BMS in case all branch valves are closed, and if there is flow that is unexpected. For example, a valve may be stuck open or a bypass left in an incorrect position. Should this be detected, the BMS can close the Energy Valve to prevent the leakage.

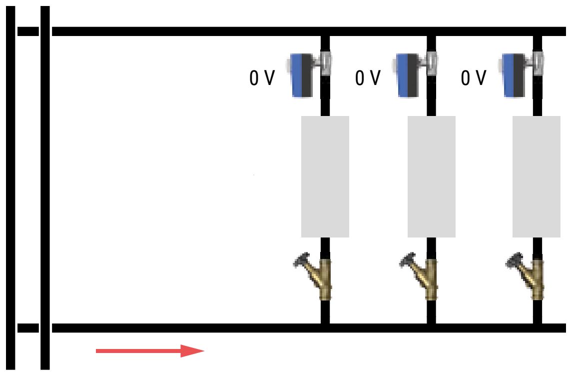


Figure 118: Classical balancing approach

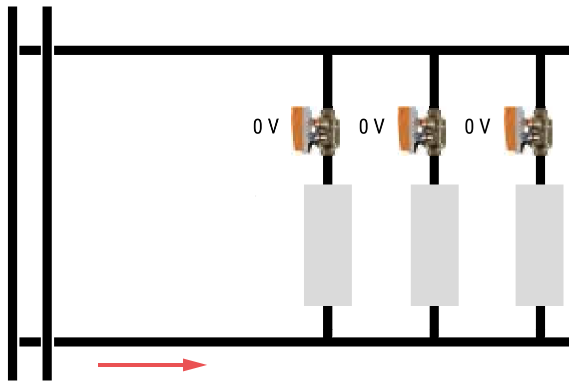


Figure 119: PIQCVs instead of a control valve and balancing valve combo

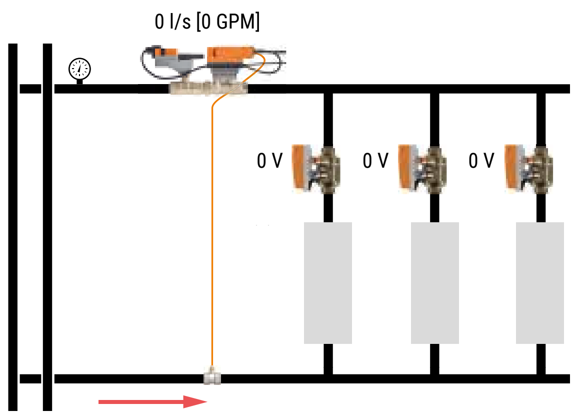


Figure 120: Dynamic balancing with monitoring

6.5 Success story

Belimo Energy Valve™ successfully used at Ludmillenstift hospital in Meppen, Germany

The Ludmillenstift hospital in Meppen, Germany, is renowned well beyond the local area for its standard of medical care, state-of-the-art diagnostic and therapeutic technology, and its pleasant atmosphere. However, a large number of modernisations over the years, in the form of extensions or modifications, resulted in problems in the hospital's hydronic distributor circuits. These have finally been rectified through the use of Belimo Energy Valves™.

Time and again, the heating system's hydraulics used to be a major headache for the building services technicians. Several rooms and zones in the hospital, which covers approximately 50,000 m^2, didn't receive adequate hot water, resulting in complaints about cold rooms. It was up to Günter Wilmink and Kristian Fitzner, the Installation and Heating Supervisors, to find a solution. Once the Belimo Energy Valves™ with built-in monitoring were fitted in the spring of 2013, the building services team was finally able to visualise the problems and gradually work its way through solving them.

The challenge

Since there were hydronic problems in the heating circuits, various departments and specialist areas on the large hospital site could not be guaranteed a supply of regular heat. Initial attempts to control the hydronics using manually adjustable, differential pressure controllers were fruitless. Pumps were also fitted, components were equipped with hydronic deflectors, the feed temperature for hot water was raised to 90 °C, and all pumps were set to maximum capacity. However, this resulted in more water flowing through the pipes, which exacerbated the hydronic problems. In the areas most badly affected, the temperature difference between the hot water's feed and return was just 5 Kelvins.

Huge increase in operating costs, as manual adjustment could not solve the dynamic problem

These changes greatly increased the costs of pumping and gas consumption – including steam generation of around one million cubic metres a year – putting strain on the hospital's budget. Peter Meier, Specialist in Control Technology at the heating firm August Brötje KG (Bremen, Stuhr), has been assisting the hospital for around 10 years, and recommended that the service technicians in Ludmillenstift take a look at the new Belimo Energy Valve™. Following a presentation by Belimo employee, Rainer Frase, which detailed what the intelligent control valve could offer and how it works, they planned installation in the highly problematic distributor circuit 1. This supplies the individual buildings housing in-patients, a residential block for staff and a hotel for family members. A total of eight Energy Valves were installed in several zones in the spring of 2013, and were linked to the existing Siemens building management system via the BACnet/IP interface.

Figure 121: Ludmillenstift hospital

The two building services technicians are constantly delighted by a special feature in the Energy Valves. The integrated web server allows the current operating data (measured by an integrated measurement sensor for water mass flow and water temperatures) to be depicted with accuracy, and accessed via a laptop or through building automation on a PC. At a glance, they can now clearly see the temperatures, water and heat flows in each hydronic circuit. A database, which stores this operating data, also enables the volumes of heat consumed to be assigned to rooms, zones or departments (cost centres) in the hospital.

7

Computer Room Air Conditioner

7.1 Application description

A Computer Room Air Conditioning (CRAC) unit is designed for applications where close control, high precision air conditioning is essential. These include data centre cooling, medium and low-density server environments, telecom switching stations, medical operating theatres and clean room environments.

Often, computer room air condition units are considered so critical that they require their own chilled water system. The continuous availability of maximum output means that the whole system cannot benefit from chilled water reset, as a CRAC unit needs water at a pre-defined temperature to ensure peak performance is always available.

Figure 122: Picture of a typical CRAC unit

7.2 Schematic

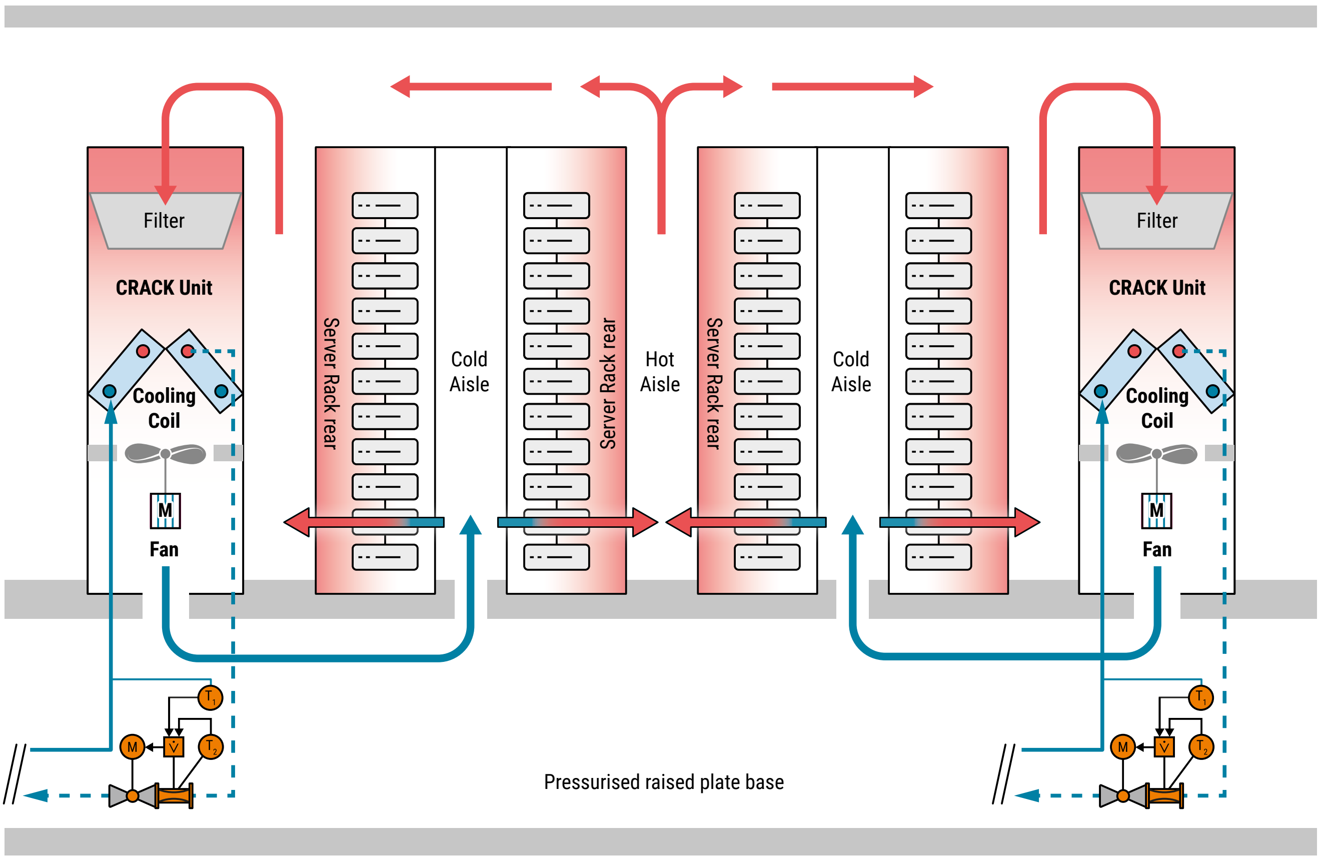


Figure 123: Schematic of a CRAC unit, including the air flow cycle to/from the racks

7.3 Common issues in CRAC units, and how the Belimo Energy Valve™ can address them

Since CRAC units require the ability to address maximum load at any time, the whole system cannot benefit from chilled water reset, as water at pre-defined temperatures is needed to ensure peak performance is always available. Given the critical nature of their task, CRAC units tend to be over selected and over commissioned. The resulting overflow cannot be converted to energy by the CRAC unit, and is reflected in elevated water temperatures or low delta T.

A Belimo Energy Valve™ using power ontrol and delta T management, can ensure that peak performance is available even with varying water temperatures.

Configure your EV to use power control, and set the design power required. The valve will then, depending on the input from the control source, modulate the power output by varying flow, depending on the delta T to achieve the desired output.

Using the formula Q = M x CP x delta T (output = mass x specific heat capacity x temperature difference), you can see that flow and delta T are linked when it comes to heat exchanger performance. We cannot change one variable without affecting the other.

Power control uses this formula to adjust the flow according to power requirements derived from the control signal DDC. Naturally, this is a slow process, so rapid changes in flow temperature do not result in rapid and repeated valve movements.

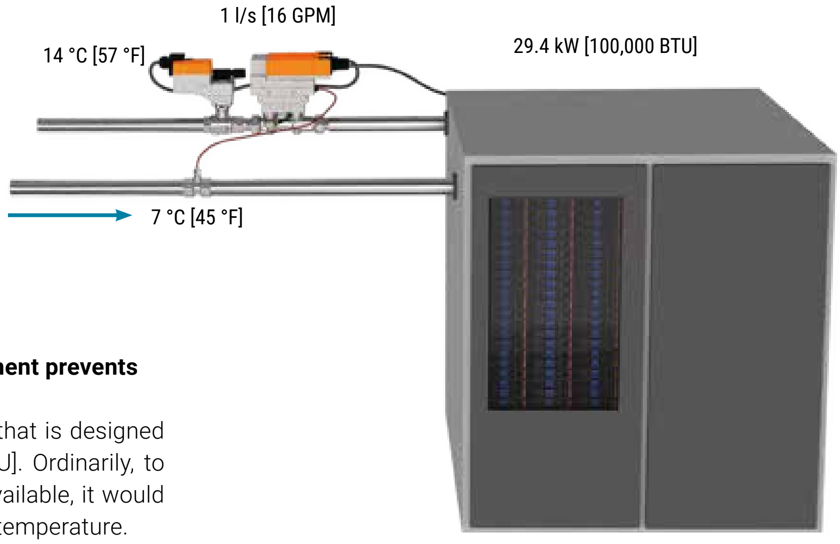
7.4 Application example

The CRAC unit, shown in figure 125, is required to deliver 29.4 kW [100,000 BTU]. It has a design flow of 1 l/s [16 GPM] and a supply temperature of 7 °C [45 °F], with an expected return temperature of 14 °C [57 °F]. This is considered 'design load' conditions.

Under low system load scenarios, the water temperature supply by the chiller may be increased for promoting energy savings. If the same unit now experiences a supply temperature of 10 °C [50 °F], the higher flow temperature could result in a lower delta T, which would reduce the available output. The Belimo Energy Valve™, having measured a lower delta T, will allow an increase in flow rate to 1.4 l/s [22 GPM] to achieve the required output. In this, the change in the supply water temperature has no adverse effect on the CRAC unit's ability to satisfy the required cooling load.

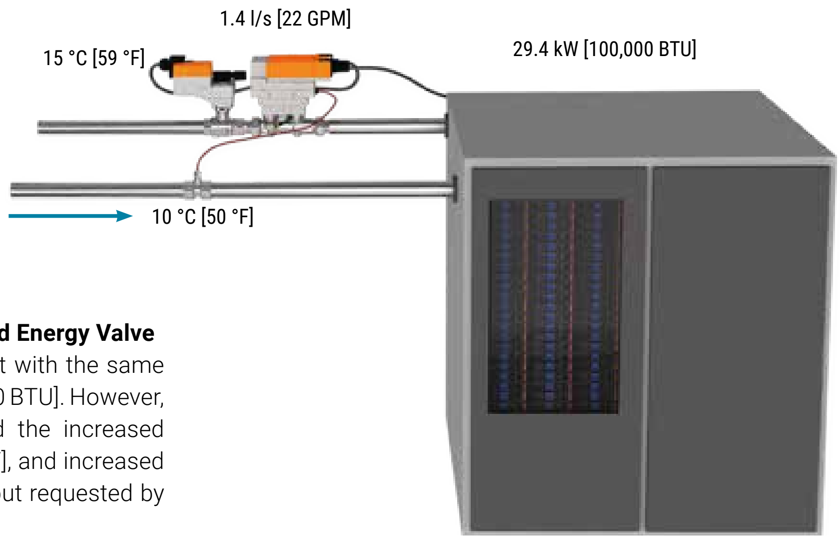
Pro Tip

Correctly set rack cooling temperatures and regularly replaced air filters can massively reduce energy consumption, and increase the endurance of IT components.



Problem: 100% output requirement prevents variable water flow rates
Figure 124 shows a CRAC unit that is designed to deliver 29.4 kW [100,000 BTU]. Ordinarily, to ensure peak output is always available, it would not be possible to vary the flow temperature.

Figure 124: CRAC unit under 'design load' conditions



Solution: Power control-enabled Energy Valve
Figure 125 shows the same unit with the same requirement for 29.4 kW [100,000 BTU]. However, the Energy Valve has detected the increased flow temperature of 10 °C [50 °F], and increased the flow rate to provide the output requested by the control signal DDC.

Figure 125: CRAC unit with higher supply temperature, for energy savings

8

Central Heating Plant

8.1 Application description

The central heating plant combines one or more heat sources into a complete system. Fossil combustion solutions, commonly referred to as oil and gas boilers, are gradually being replaced or supplemented with alternative solutions. Heat pumps or renewable forms of heat generation, such as thermal solar systems, are on the rise and help to reduce CO_2 emissions.

The energy efficiency in a boiler room depends on the careful selection of the heat generator and the use of suitable piping for the hydronic distribution, as well as consumer circuits with high quality valves that control precisely and close 'air bubble tight' when not in operation.

Figure 126: Condensing gas boiler

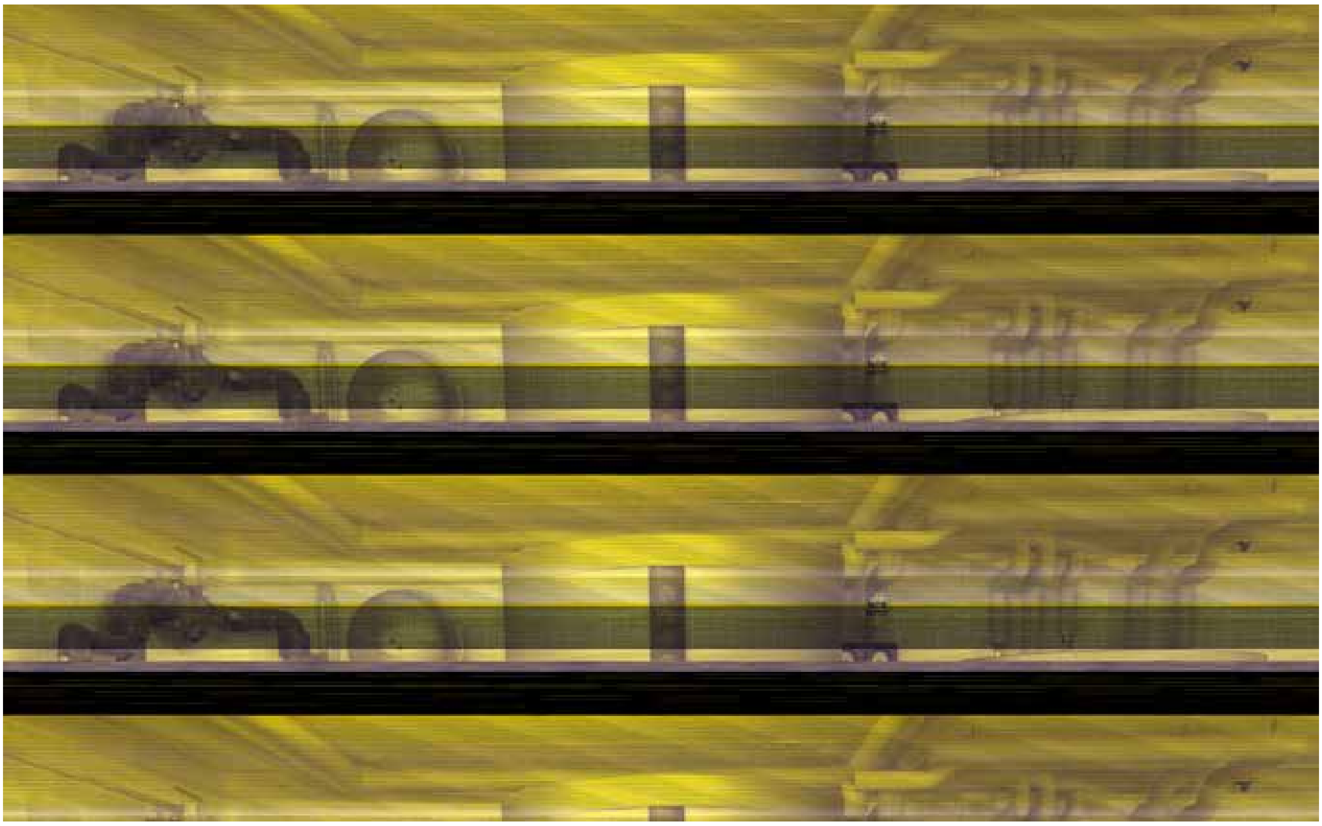


Figure 127: Heat pump with potable hot water storage tank

8.2 Schematic

Modern central heating plant systems are often more complex and require more transparent monitoring to ensure that the targeted savings are actually achieved in practice. The Belimo Energy Valve™ is a great tool to create transparency and ensure correct long-time operation of the heating plant.

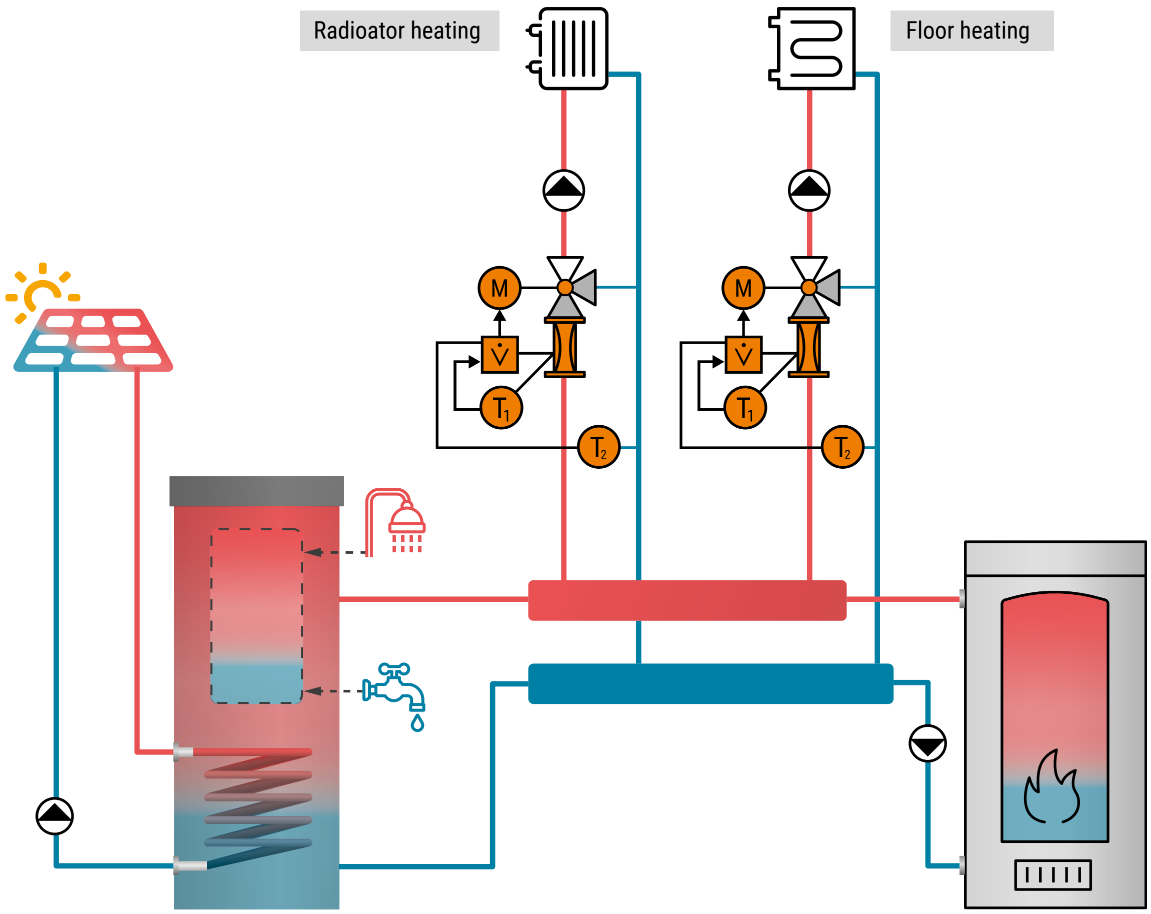


Figure 128: Typical hydronic schematic of a central heating plant that combines multiple alternative and renewable energy sources

8.3 Common issues with non-condensing boilers, and how the Belimo Energy Valve™ addresses them

Retrofitting an EV in an existing installation will not only ensure that the valve will eliminate hidden water flow circulation in standby periods, it will also create full system transparency (volumetric flow, power, temperatures, and cooling/heating output) with data recording and optional Belimo Cloud connection.

Problem: Poor performance of outdated old boiler designs
Non-condensing boilers are often equipped with a 3-way globe valve to prevent condensation inside the boiler during startup, as this would lead to corrosion and, over time, to failure of the boiler. The 3-way globe valve is often positioned with caution, allowing a small amount of flow back to the return, even after the warm up process is complete, as shown in figure 129.

Solution: Energy Valve retrofit
Retrofitting the EV to an existing non-condensing boiler will help to monitor your existing installation and allow the system to sense when the return water temperature is above the minimum level, and close the bypass valve completely, as shown in figure 130.

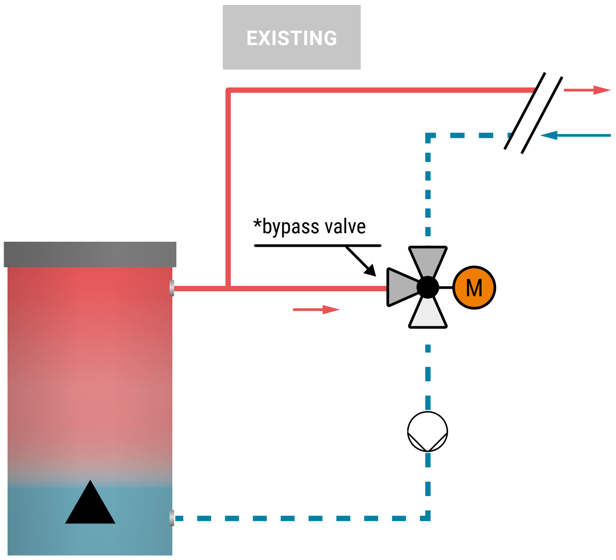


Figure 129: Boiler with a globe valve
*bypass valve to prevent condensation during startup

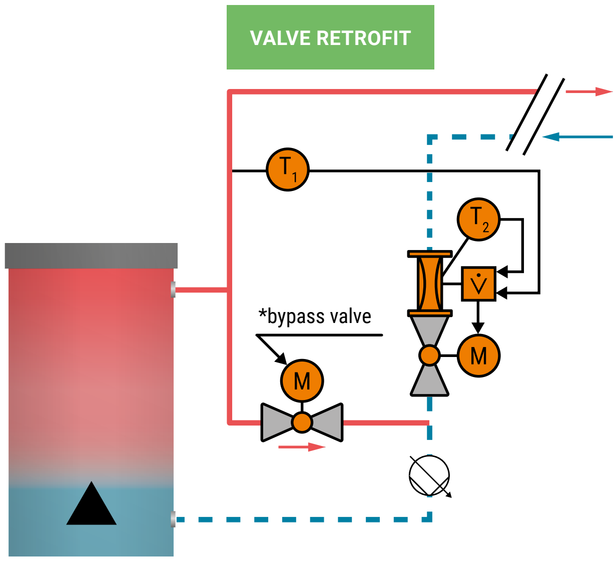


Figure 130: A non-condensing boiler retrofitted with an 'air bubble tight' bypass valve and an Energy Valve

Problem: Poor energy efficiency of condensing boiler
Condensing boilers achieve high efficiency (typically greater than 90%) by condensing water vapour in the exhaust gases, recovering its latent heat, which would otherwise have been wasted. This condensed vapour leaves the system in liquid form, via a drain. The return water temperature to the boiler must be below the dew point of the incoming fuel, to permit the condensing process to occur.

When coils or radiators are unable to transfer the required amount of energy, the resulting elevated return water temperatures prevent the boiler from condensing, dramatically reducing the efficiency of the boiler.

Solution: Boiler replacement and Energy Valve retrofit
The EV will log temperature and flow, to help determine the correct flow of the pump, ensuring your return water temperature remains below the dew point of the incoming fuel. This minimising pump energy and maximising boiler efficiency.

Thanks to the EV, you can now constantly monitor the return temperature from your consumers. You will be able to identify hydronic problems of your existing installations. These are often:

- Open bypass valves flooding your circuit with hot water, not supplying remote consumers
- Valves in closed positions that are leaking/passing, resulting in ghost energy
- Foul coils not able to transfer the required power
- Scale in potable hot water tanks
- Blocked strainers

Pro Tip

The type of fuel the condensing boiler uses, decides the ideal return water temperature.

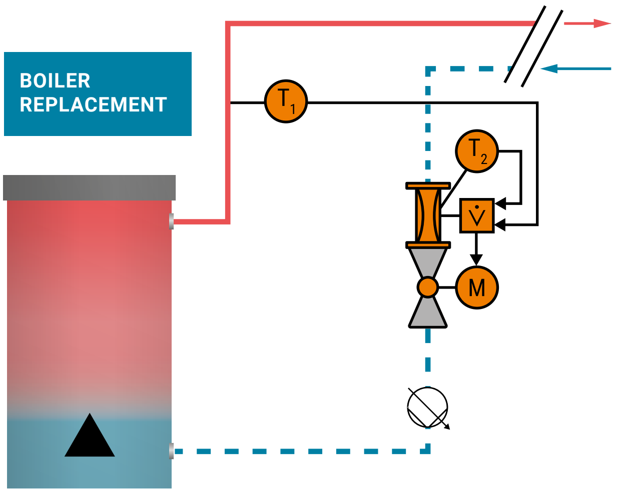


Figure 131: A condensing boiler equipped with an 'air bubble tight' EV

8.4 Heating valve applications

Both injection and mixing circuits offer the capability to deliver different temperatures to different circuits, but are complex and require additional equipment. Throttling control valves offer numerous efficiency advantages, but are not able to deliver different flows temperatures to different circuits. Figure 132 shows the different piping options.

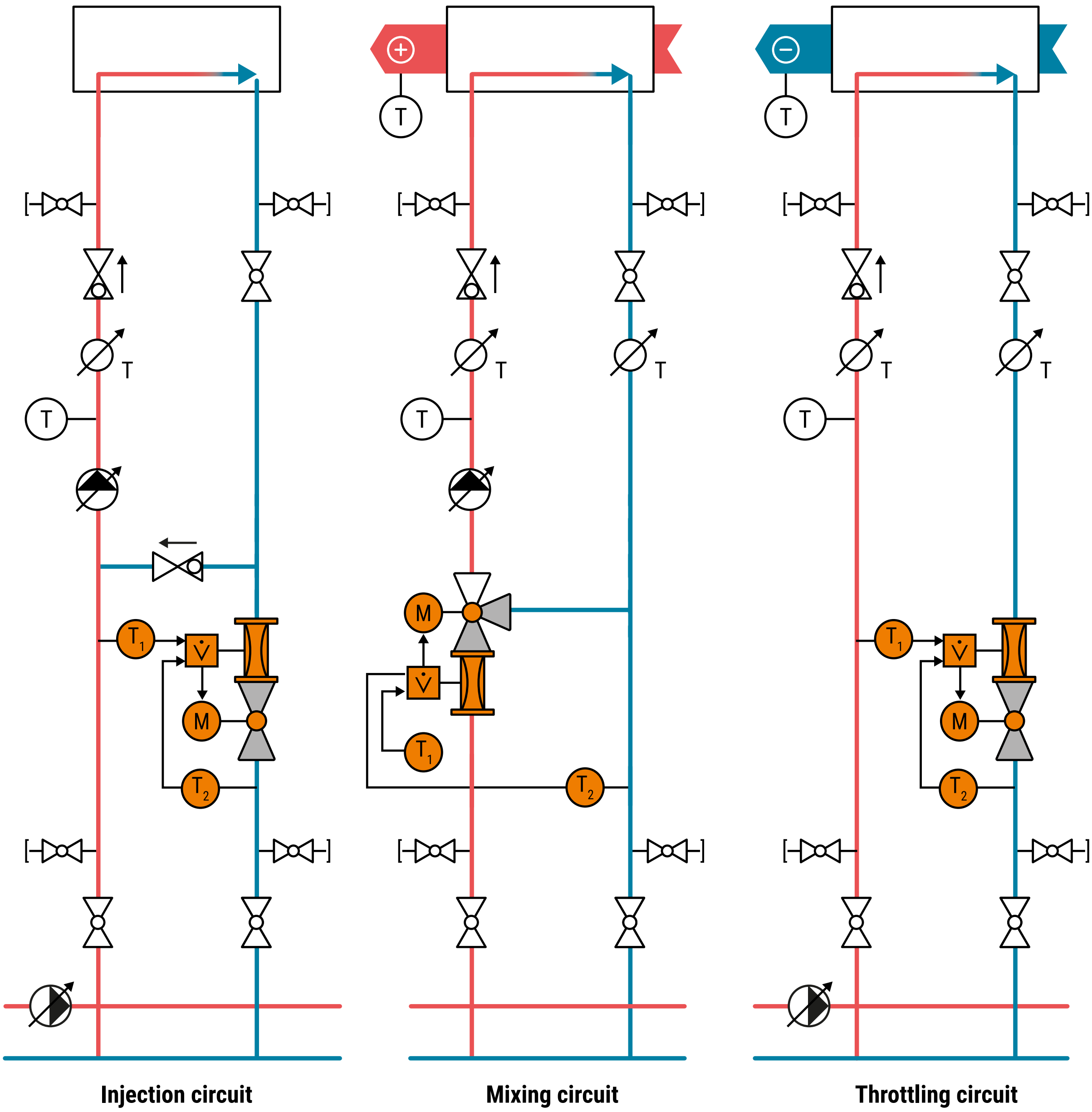


Figure 132: An overview of the different valve configurations for heating

9

Chiller/Heat Pump Monitoring

9.1 Application description

Chillers and heat pumps come in a huge variety of shapes and sizes, using different technology to achieve the same outcome for the exchange of energy.

The efficiency of this process is measured by the ratio of usable energy (media water, water/glycol or air) to the energy used (typically electricity). Both measures have units of BTU/(h·W) (1 BTU/(h·W) = 0.293 W/W).

Monitoring water supply temperature, flow rate and water return temperature is an important part of the process. The first step in improving chiller operating efficiency is to calculate current conditions (produced energy/consumed electricity), known as COP.

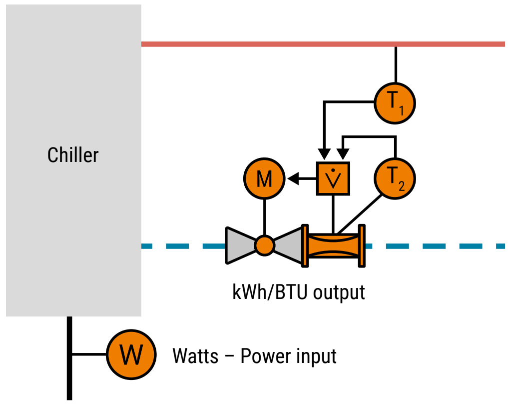


Figure 134: Chiller/heat pump with indicated cooling circuit

$$\text{COP} = \frac{\text{COOLING POWER}}{\text{INPUT POWER}}$$

Figure 133: Standard efficiency calculation formula for a chiller. For more details and heat pump calculations, refer to industry standards

9.2 Schematic

There is not one generic schematic valid for all kinds of chiller or heat pump piping. Figure 134 shows an Energy Valve fitted to monitor flow and delta T through a chiller.

However, they all have one thing in common; their maximum achievable power depends on the volume flow x delta T. Too small delta T limits the output of the plant. Often in low delta T situations, more machines are running than are actually required, as there capacity is limited.

The Belimo Energy Valve™ is a great product to create transparency and ensure correct long-time operation. Belimo do not recommend the correction of delta T issues at the plant. Implementation of any type of control here may starve some units and not deal with others, which are creating the issue.

9.3 Total cost of ownership (TCO)

Often, the symptoms of low delta T is presented as a lack of capacity from the plant during peak periods. This naturally leads to the instinct to increase the capacity. Using the Energy Valve to diagnose and actively correct low delta T at the heat exchangers, can prevent the need to upgrade entirely.

9.4 Common issues with chillers and heat pumps, and how the Belimo Energy Valve™ addresses them

Problem: Ongoing monitoring of chiller performance
In older chillers, it is difficult to monitor thermal output. Ideally, we want this to compare against the power consumed for a true COP. Historical benchmarking has become increasingly important in recent time. The capability to measure performance against this time last year or against a time with similar conditions, enhances informed decisions on maintenance and replacement.

Solution: Use the Energy Valve built-in energy meter
By monitoring the flow rate, along with entering and leaving water temperatures, you can build a good picture of how well your chiller is performing thermally, and with the addition of an electrical consumption meter, you can obtain the whole picture or coefficient of performance (COP). Even if your chiller already offers real time output data, the Energy Valve is able to monitor and log this data for 13 months and provides a useful backup if the on-board feature fails.

Problem: Unknown glycol levels
Glycol is heavier than water, so too much reduces your pump efficiency, and with too little, there is a risk of freezing. Getting this level right requires testing of the water. This is often a manual process reliant on facility management staff remembering to conduct the tests, but this manual process leads to a fear of a lack of glycol, which often leads to overdosing.

Solution: Continuous glycol monitoring
The primary chilled water circuit is the best place to monitor the levels of this important part of your water. Energy Valves monitor glycol concentrations in the hydronic circuit and the BMS can alarm, or even auto-dose the system, if the level should fall below a predetermined limit.

By monitoring and logging the glycol content, you can manage the balance between too excessive and insufficient concentrations in the system.

Energy Valves automatically adjust the thermal energy calculation based on the level and type of glycol in the system which could otherwise affect the readings by 30%.

Figure 135: COP analyses are only possible when data is logged

Figure 136: EV-integrated energy data logging

Figure 137: The fear of pipework failure is often the driver for overdosing of glycol and increased pump energy consumption

9.5 Success story

The Belimo Energy Valve™ cures medical university's low delta T

The University of Miami medical campus saves thousands of dollars and increased plant capacity with the Belimo Energy Valve retrofit.

The University of Miami's M. Miller School of Medicine

The School of Medicine says it prides itself on bringing medical research from 'bench to bedside', meaning doctors are providing patients in Southern Florida with the latest cutting-edge developments in medical care. On its sprawling campus and in its state-of-the-art buildings, doctors and researchers are unlocking the secrets to not only infectious diseases, but the future of stem cells and genetics.

What many people may not know is the preventive care that is going on behind the scenes when it comes to the university's mechanical systems. At the heart of the university is a 47,000 sq ft chiller plant with 12,000 tons of installed capacity, providing the much needed cooling and chilled water for its hospitals and research buildings. While the chiller plant is still fairly new, having just opened in 2011, some buildings on campus were not operating as efficiently as they could, wasting thousands of gallons of chilled water. However, the problem was not with the chiller plant, but the cooling coils in several of the campus facilities.

The solution to the problem came in the form of the latest research and development from Belimo — the Belimo Energy Valve™.

The diagnosis – low delta T

Low delta T is a common mechanical problem. It occurs when air handling coils are oversized, demand too much water, or foul and degrade with age. Poor system water balance, and improperly installed and controlled air handlers can also contribute to low delta T.

When this happens, air handler efficiency and heat transfer plummets. In turn, chillers and pumps work overtime in order to maintain a given temperature setpoint. Return water temperature to the chiller is lower than the intended design, forcing more water to be pumped through the system. As more and more gallons of water move through the system, not only is efficiency in question, but utility costs can go through the roof.

This was the diagnosis for some of the buildings on the University of Miami medical campus. Even with a new chiller plant, and a mix of new and older facilities, low delta T was negatively impacting the efficiency on campus — that is until Kerney and Associates of Dania Beach, FL, stepped in.

Figure 138: The University of Miami's medical campus

The speciality piping and energy services company has had the University of Miami medical campus as a client for several years, so when they learned about the Belimo Energy Valve™, they knew it was something they had to share with the university, especially since Kerney and Associates specialises in retrofit opportunities that will provide a maximum return on investment for clients.

"We do a lot of business with them," said Ron Bogue, Assistant Vice President for Facilities and Services at the University of Miami Medical campus. "They came to us and introduced us to the Belimo Energy Valve line."

The Energy Valve is a pressure independent valve that optimises and documents water coil performance. The valve includes an ultrasonic flow sensor and temperature sensors that monitors supply and return water. Differential temperature is monitored to make sure that the delta T across the valve is performing at the desired setpoint. If delta T drops, the valve modulates the flow of water at the coil, which improves system efficiency.

PART C

Installation and Configuration

OVERVIEW OF SETTINGS

1 Configuration 118

2 Glossary 120

1

Configuration

1.1 The Belimo Energy Valve™ can be ordered in two different ways

1. Default settings

The product is shipped with the default settings, as shown below. Setup of the flow rates and control modes will need to be accomplished on site, however, this is easy to do using the App or web server.

Maximum Flow	Installation Position	Delta T Manager	Delta T Setpoint	Actuator Setup	Control and Feedback Signal	Control Mode
Maximum Flow of the Valve	Return	Off	5.6 °C [10 °F]	Non-Fail-Safe Normally Closed (NC)	Control signal DDC (Y) DC 2 to 10 V	Position Control
				Electronic Fail-Safe Normally Closed (NC)/Fail Closed (FC)	Feedback Signal (U) DC 2 to 10 V	

Figure 139: Default settings of the EV

2. Pre-programmed

The product can be shipped pre-configured to your requirements. Note: if no specific settings are selected, the product will be shipped with the default settings, as shown above.

2

Glossary

AHU (air handling unit)
A device used to condition and circulate air as part of a heating, ventilating, and air-conditioning system.

Analogue signal
A linear signal from one device to another, which is used to write or read values. For example, a controller may use an analogue signal to modulate an actuator. Typical analogue signal ranges are 2-10 VDC, 0-10 VDC, or 4-20 mA for HVAC applications.

ASHRAE 90.1
An American National Standard published by ASHRAE and jointly sponsored by the IES, which provides minimum requirements of energy-efficient designs for buildings, excluding low-rise residential buildings.

BACnet
A standard worldwide communication protocol that is used in building automation. BACnet IP communicates over Ethernet networks and BACnet MS/TP, over 2 or 3-wire RS485 networks.

BMS (building management system) and BAS (building automation system)
A computer-based controls system installed in buildings to control and monitor the building's mechanical and electrical equipment.

Calculated/theoretical flow
A calculated and therefore theoretical flow is obtained by assuming a flow rate based on valve position. This method is not precise as all requirements for pressure need to be met. It is most often seen in mechanical PI valves.

CCV (Characterized Control Valve)
A Belimo patented ball valve with a characterising disc that provides equal percentage flow characteristic with high range ability, zero leakage, and high close-off.

Coil
A water to air heat exchanger, typically made of copper tubes passed through aluminium fins, and is used in AHUs, fan coils, etc.

DDC (Direct Digital Control)
An electronic controller with software to operate control valves, dampers and other devices.

Delta T, ΔT, or DT
The differential temperature between the supply and return media. In HVAC applications, this is typically the difference of air or water temperatures after moving through a heat transfer device.

Delta T limit value
A setting used by the Delta T Manager to limit coil overflow.

Delta T Manager
A Belimo patented flow limiting logic applied to the Belimo Energy Valve™ control modes.

Delta T Manager scaling
An option in the Delta T Manager logic that produces a variably scaled delta T setpoint.

Delta T setpoint
The setpoint used by the Delta T Manager logic. When used with Delta T Manager, it is a fixed setting. When used with Delta T Manager Scaling, it becomes a calculated variable over a scaled range.

Dynamic balancing
A method that compensates all pressure fluctuations in the system, to make sure the required flow is delivered to each point in the system.

ePIV (electronic Pressure Independent Valve)
With true flow measurement

Equal percentage flow curve
An equal percentage flow characteristic is a non-linear curve where the slope increases as the valve opens, while a linear flow characteristic is a straight line.

EV (Belimo Energy Valve™)
A smart control valve consisting of an ultrasonic flow sensor, a characterised control valve, an actuator, two temperature sensors and an embedded control logic, which allows for power control in a hydronic circuit.

Fixed Delta T Manager
An option in the Delta T Manager logic that produces a fixed delta T setpoint.

Flow limit value/flow saturation
A setting used with Delta T Manager scaling to reset the delta T limit value, and create a variable, delta T setpoint.

Ghost energy
Leaking or passing control valves can create ghost heating and cooling demands, and excess ventilation, which comes with a need to dehumidify or preheat. Also, there is ghost pumping for the additional chilled water and heating water flows along with ghost heating and cooling. A 1% leakage creates a 5 to 10% loss of energy.

Hysteresis
A phenomenon typically associated with the springs in mechanical PI valves. When pressure changes, a spring which controls the diaphragm position starts to be compressed or stretched, therefore maintaining the PI functionality and impacting very little on the control device, resulting in a minor variation of flow.

KPI
A key performance indicator is a type of performance measurement. In our context, KPIs evaluate the success of the Belimo Energy Valve™.

Modbus
A type of bus communication that can integrate the device to the controller over a bus. It can be wired in either RTU or IP configuration.

MP-Bus or MP
Belimo MP-Bus is a combined 24 V power and signal standard to connect a master actuator with up to 16 slaves. It can also be used with the ZTH US tool to view and change actuator settings.

PI valves, PIV, or PICV
This is the way to refer to pressure independent control valves.

P'max
The maximum thermal power setting.

P'nom
The maximum thermal power of the heat exchanger.

Pressure independent VAV
A pressure independent VAV measures airflow and will maintain it regardless of the box inlet static pressure provided by the main air handling unit.

PT ports
Pressure and temperature ports on a device that can measure both variables in the system.

Transit time technology
The transit time method of measurement is the most commonly used in ultrasonic metering. A pulse or pulses are transmitted to and from transducers through the liquid, to the opposing transducer positioned further downstream. Sound waves travel faster with the direction of flow and slower against the direction of flow. This principle is used for the measurement.

True flow
An accurate flow rate as obtained from a wet calibrated flow meter.

Valve authority
A term used to describe the basis on which a control valve is selected. The valve authority is generally defined as the ratio of the pressure drop across the fully open valve compared to the pressure drop across the entire circuit at design flow conditions.

Valve's coefficient
The valve's coefficient (also known as flow coefficient)of a valve is a relative measure of its efficiency for allowing fluid flow. It describes the relationship between the pressure drop across the valve and the corresponding flow rate.

Variable flow systems
A type of system that delivers variable water depending on the required load. This can be accomplished by using a VFD (variable frequency drive) or a bypass valve.

VAV
Variable Air Volume is a type of HVAC system. VAV systems vary the airflow to provide a constant space temperature and/or a defined amount of air per hour.

Venturi
It creates a constriction within a pipe that varies the flow characteristics of a fluid travelling through the orifice.

V'max
The maximum valve flow setting. A value inputted to set the maximum flow to be delivered by the valve.

V'nom
The maximum valve flow value.

Wet calibrated
A sensor calibration method using actual fluid flow. This normally provides the highest calibration accuracy for a flow meter, and sees use where accuracy is a prime concern or when the form of the meter does not lend itself to other methods.

SPACE FOR NOTES

SPACE FOR NOTES

SPACE FOR NOTES

All inclusive.

Belimo as a global market leader develops innovative solutions for the controlling of heating, ventilation and air-conditioning systems. Actuators, valves and sensors represent our core business.

Always focusing on customer added value, we deliver more than only products. We offer you the complete product range for the regulation and control of HVAC systems from a single source. At the same time, we rely on tested Swiss quality with a five-year warranty. Our worldwide representatives in over 80 countries guarantee short delivery times and comprehensive support through the entire product life. Belimo does indeed include everything.

The "small" Belimo devices have a big impact on comfort, energy efficiency, safety, installation and maintenance.

In short: Small devices, big impact.

- 5-year warranty
- On site around the globe
- Complete product range
- Tested quality
- Short delivery times
- Comprehensive support

EN – 12.2021 – Subject to technical modifications

BELIMO Automation AG
Brunnenbachstrasse 1, 8340 Hinwil, Switzerland
+41 43 843 61 11, info@belimo.ch, www.belimo.com