ASHRAE Hellenic Chapter

WEBINAR ON

OPTIMIZING HYDRONIC SYSTEMS

WEDNESDAY 26 MAY 2021 @ 6:00 p.m.

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OPTIMIZING HYDRONIC SYSTEMS

WEDNESDAY 26 MAY 2021 @ 6:00 p.m.

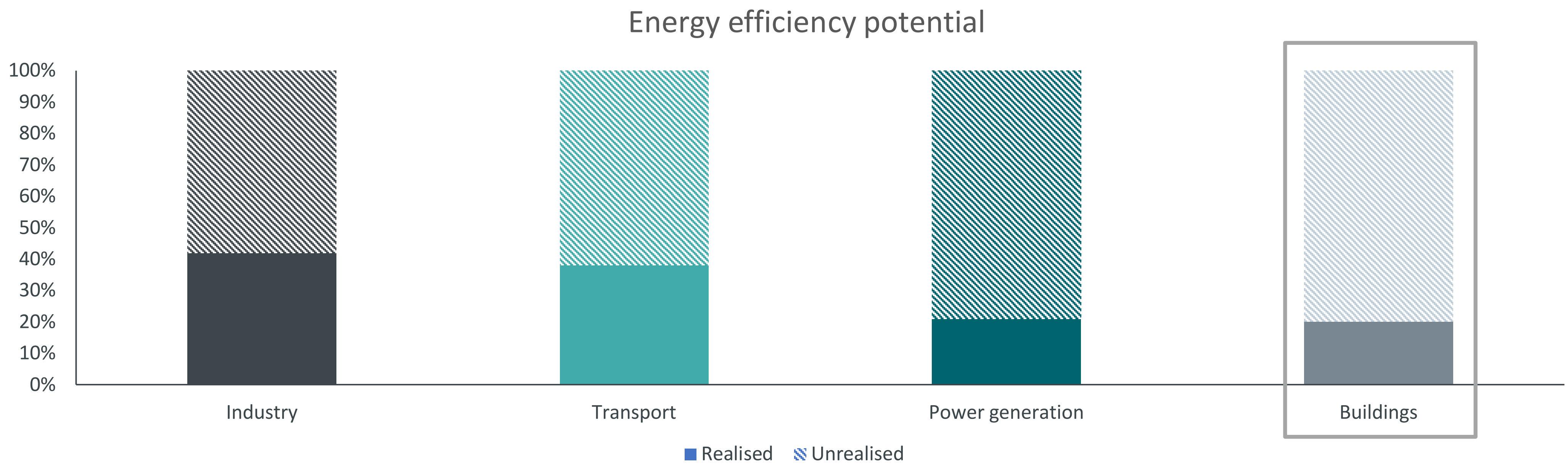
SIEMENS

How to improve ΔT and save more energy with PICV and Intelligent Valves

Voulvoutzis George / Product specialist

Optimize your hydronic building flow

80% of Buildings Efficiency Potential remains untapped



Definition of Energy Efficiency

"Using less energy without compromising the performance of the building"

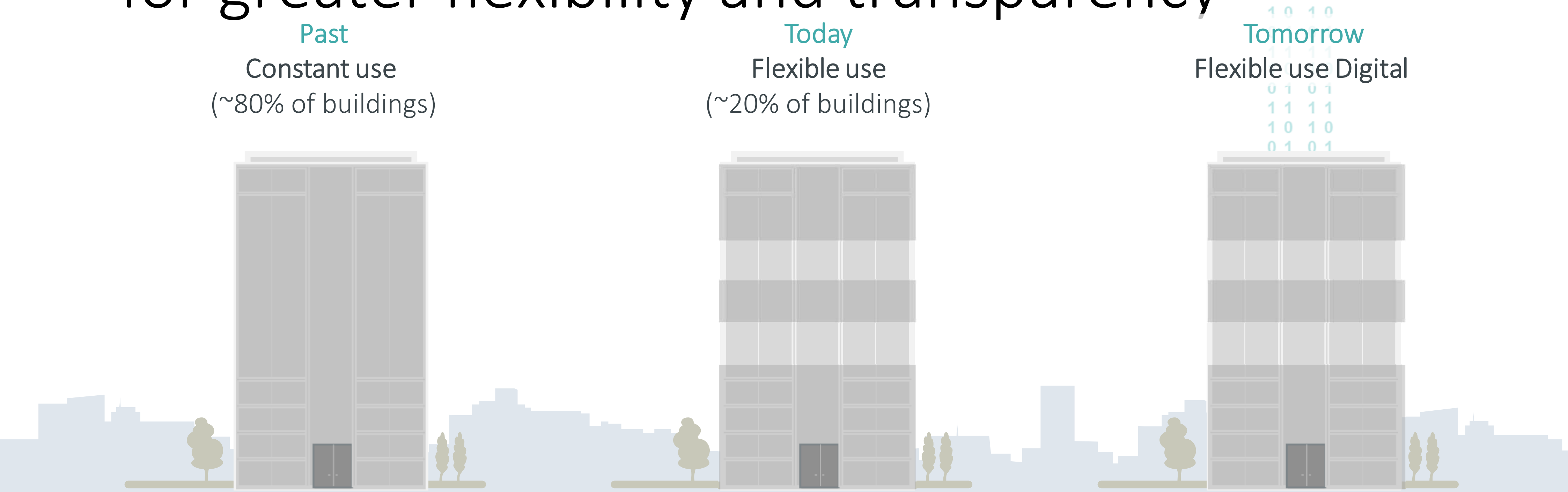
Source: IEA World Energy Outlook (2012), energy.gov https://bit.ly/2p8PZ6s (2017), Energy 2020 European Commission (2011), United Nations Environmental Program (UNEP) and United States Environmental Protection Agency (EPA)

Modern buildings need designs for greater flexibility and transparency

Past
Constant use
(~80% of buildings)

Today
Flexible use
(~20% of buildings)

Tomorrow
Flexible use Digital

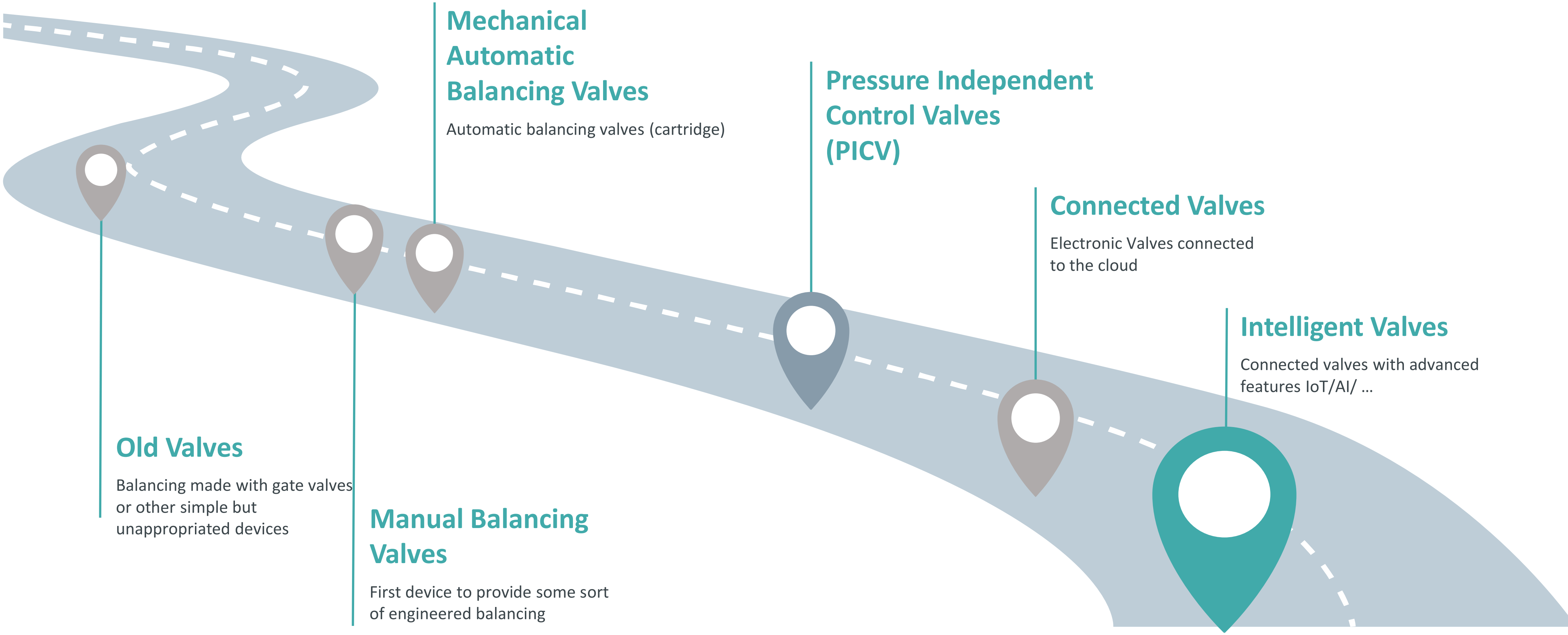


- Made between before 2000
- Constant air and water distribution
- Static flow balancing made for worst case
- 100% Energy consumption

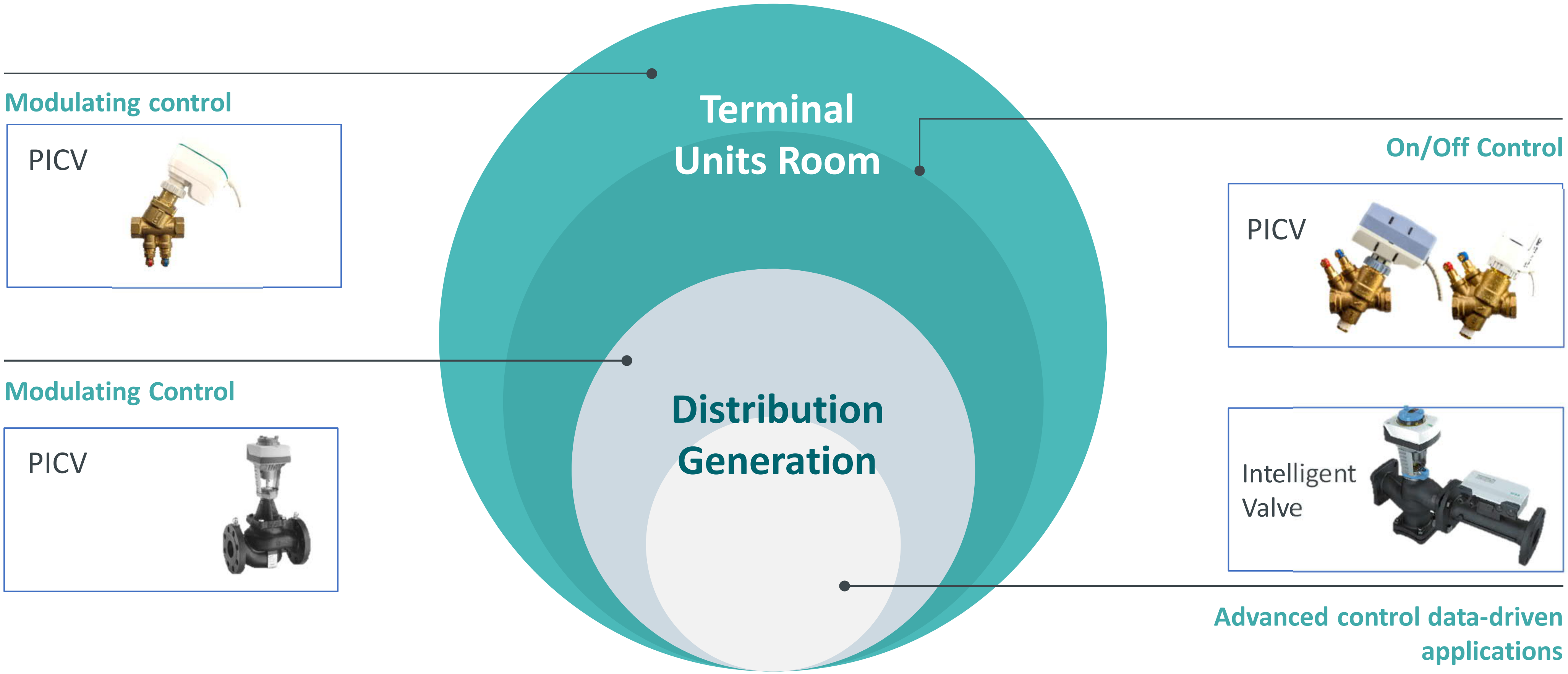
- New energy requirements
- Variable air and flow distribution
- Static commissioning to perform for the whole building

- High flexibility in use
- Distributed function
- Demand control based on additional data
- Dynamic commissioning

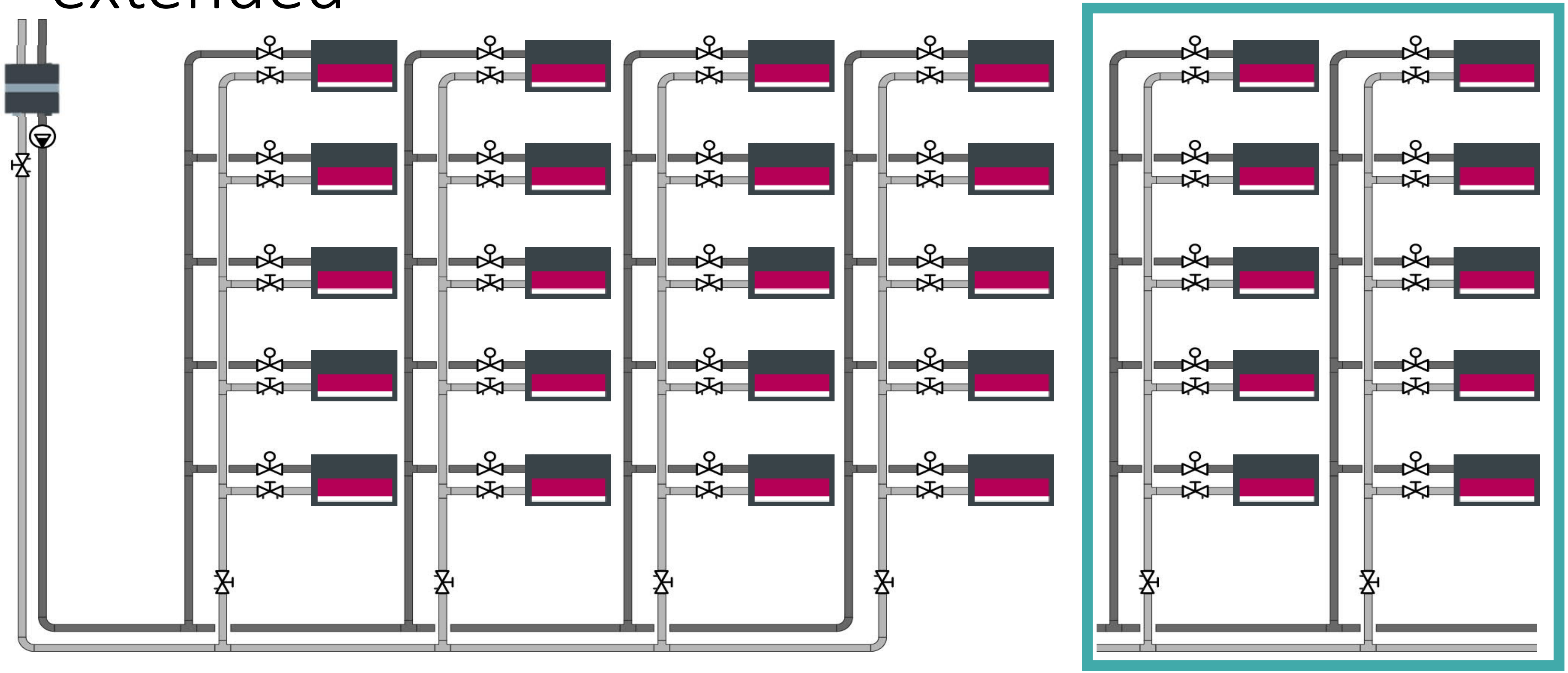
Hydronic Balancing – History



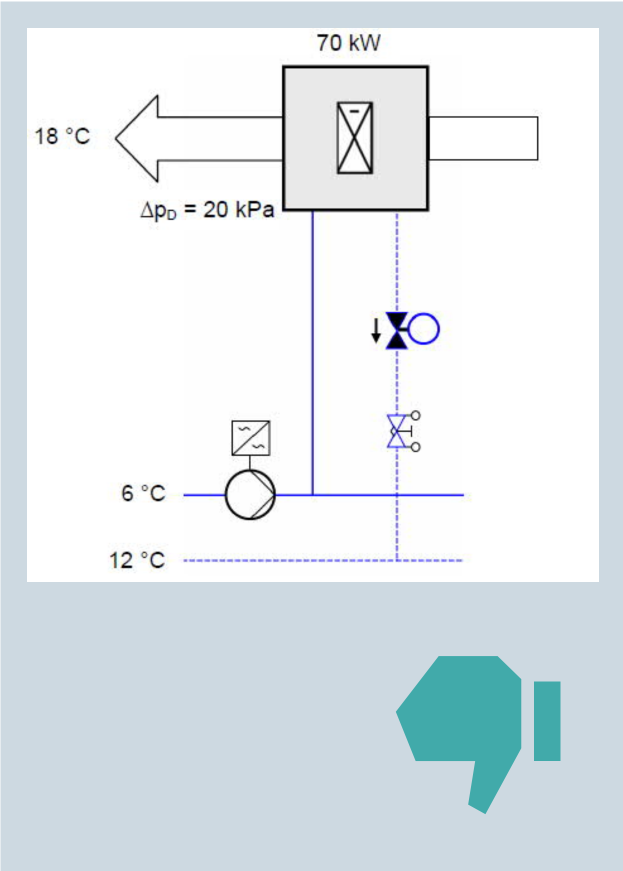
Dynamic balancing solutions by application



Hydronic distribution system must be extended



Traditional design of hydronic control circuit



Calculating of the k_{VS}-value

This means that all basic data is now available to calculate the key characteristics Δp_{V100}, $\dot{V}_{100}$ and the k_{VS}-value that are required for sizing the valve:

Definition of the k_{VS}-value according to VDI 2173 is:
Δp_0 = 1 bar (respectively 100 kPa) across the fully opened valve (nominal stroke H_{100})

The determination of the k_{VS}-value is based on the 2nd proportional law:
(see chapter: 2.4.1, Plant characteristic (piping network characteristic))

$$\frac{\Delta p_1}{\Delta p_2} = \left(\frac{\dot{V}_1}{\dot{V}_2}\right)^2$$

In this context:

$$\frac{\Delta p_{V100}}{\Delta p_0} = \left(\frac{\dot{V}_{100}}{k_{VS}}\right)^2$$

Solve the equation for k_{VS}:

$$k_{VS} = \dot{V}_{100} \cdot \sqrt{\frac{\Delta p_0}{\Delta p_{V100}}}$$

Determination of the other terms:

$$P_V = \frac{\Delta p_{V100}}{\Delta p_{V100} + \Delta p_D}$$

Solve the equation for Δp_{V100}:

$$\Delta p_{V100} = \frac{P_V \cdot \Delta p_D}{1 - P_V} \quad \Rightarrow \Delta p_{V100} = \frac{0.45 \cdot 10\ \text{kPa}}{1 - 0.45} = 8.2\ \text{kPa}$$

$$\dot{V}_{100} = \dot{Q}_{100} \cdot \frac{0.86}{\vartheta_{1e} - \vartheta_{1a}} \quad \Rightarrow \dot{V}_{100} = 20\ \text{kPa} \cdot \frac{0.86}{20\ \text{K}} = 0.86\ \text{m}^3/\text{h} \quad \Rightarrow k_{VS\ desired} = 0.86\ \text{m}^3/\text{h} \cdot \sqrt{\frac{100\ \text{kPa}}{8.2\ \text{kPa}}} = 3.0\ \text{m}^3/\text{h}$$

Note:
The factor 0.86 consists of the specific heat capacity of water c_W = 4.187 kJ/(kg·K), the density ρ = 1000 kg/m³, the transformation from 1 kW to 1 kJ/s and the conversion from s to h.

Appendix: Calculating the a-value

Definition of the a-value:

In general:

$$a = f \cdot \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{1a0}}$$

For practical applications under near zero load conditions: $(\dot{V}_0 = \dot{V}_{min} > 0)$

$$a = f \cdot \frac{\Delta T_{primary\ design\ load}}{\Delta T_{primary\ zero\ load}}$$

Formulas used for calculating the a-value:

Radiators

Range approx. 0.5 … 0.65 (supplier's specification, room control affecting mixture)

Floor heating systems

Range approx. ca. 0.8 … 0.9 (supplier's specification, room control affecting misture)

Supply temperature control

For example mixing circuit: a = 1

Mixing circuits, water → water, f = 1

ϑ_{2a} controlled:

$$a = \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2a}}$$

ϑ_{2e} constant, ϑ_{2a} not controlled:

$$a = \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2e}}$$

Mixing circuits, water → air, f = 1

Preheating coil ϑ_{2a} controlled:

$$a = \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2a}}$$

Reheating coil ϑ_{2a} or room temperature controlled:

$$a = \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2e}}$$

For flow control, water → water, $f_{parallel\ flow} = 2$; $f_{counter\ flow} = 1$

ϑ_{2a} controlled:

$$a = f \cdot \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2a}}$$

ϑ_{2e} constant, ϑ_{2a} not controlled:

$$a = f \cdot \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2e}}$$

For flow control, water → air, f = 0.6

Preheating coil ϑ_{2a} controlled:

$$a = 0.6 \cdot \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2a}}$$

Air heating / cooling coil, ϑ_{2a} or room temperature controlled:

$$a = 0.6 \cdot \frac{\vartheta_{1e} - \vartheta_{1a100}}{\vartheta_{1e} - \vartheta_{2e}}$$

PICVs in a nutshell

1 Control valve actuator

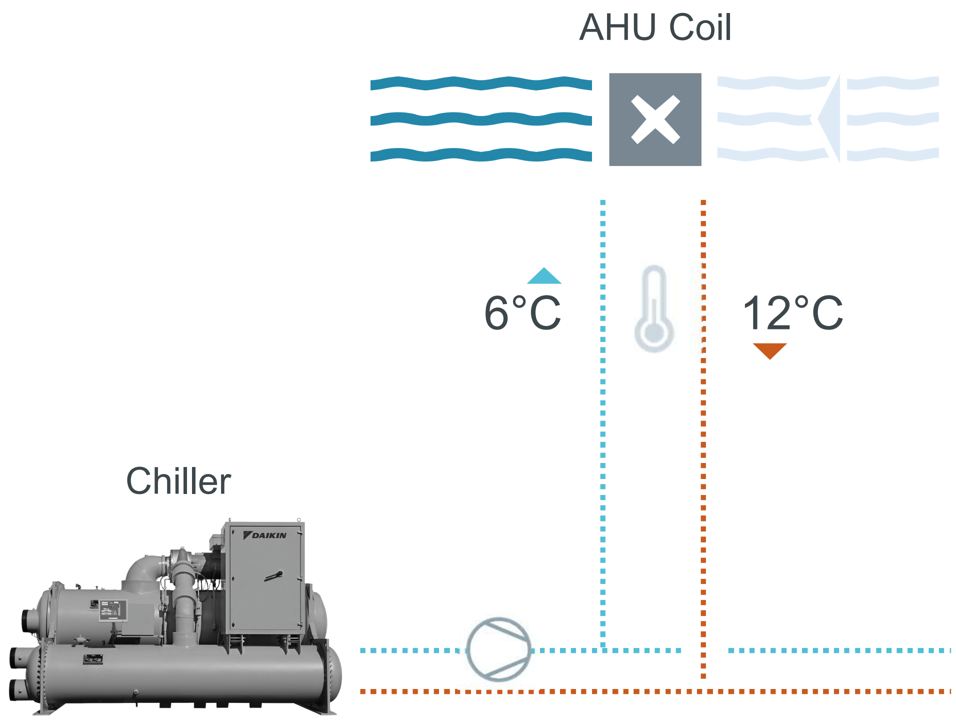
2 Continuous presetting of required maximum volumetric flow

3 Integrated differential pressure controller

4 Pressure test points

Energy performance

Example using a cooling application

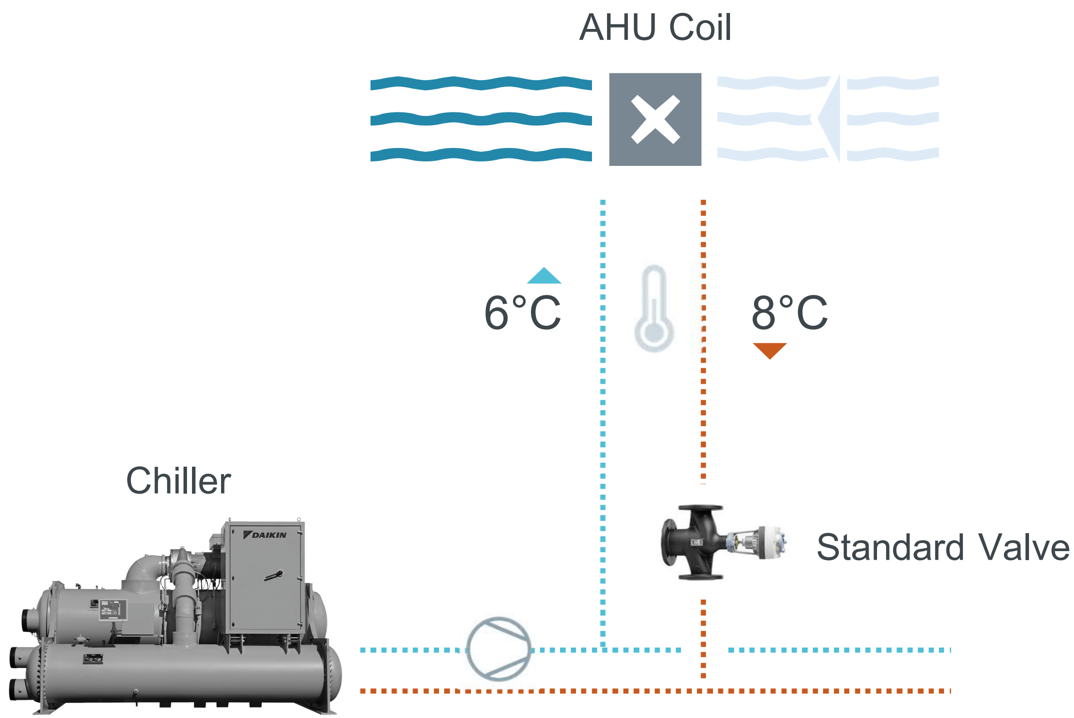


Cooling application

At full load ΔT: 6 K

Chiller efficient

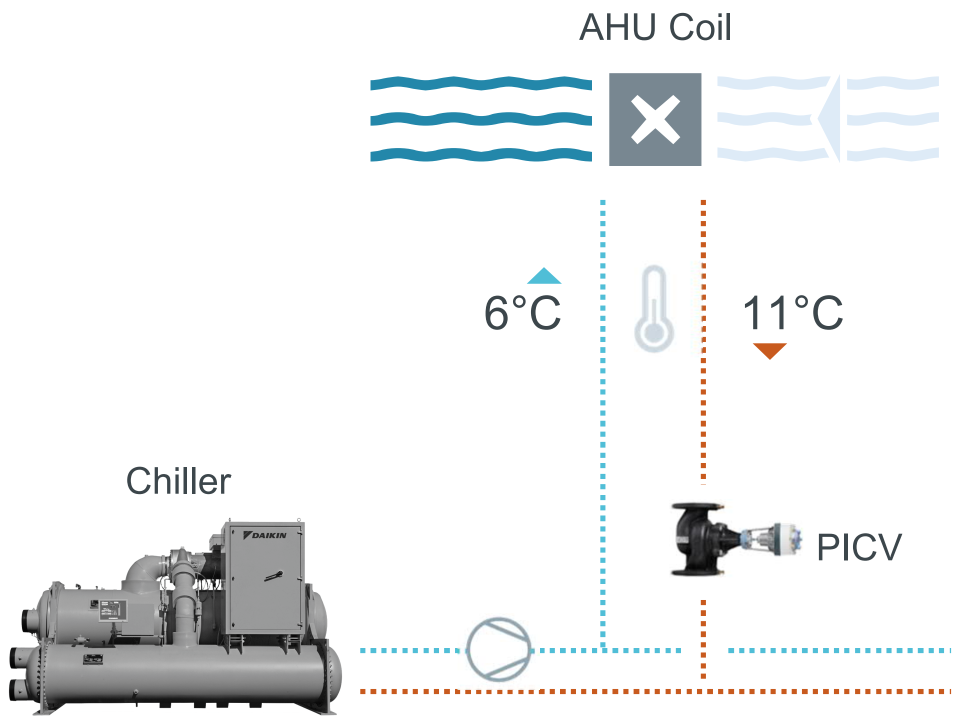
Situation with static balancing



Typical risks:

- Peaks, e.g. 25% overflow
- Oversupply leads to ΔT: 2 K
- Chiller not efficient
- High power consumption

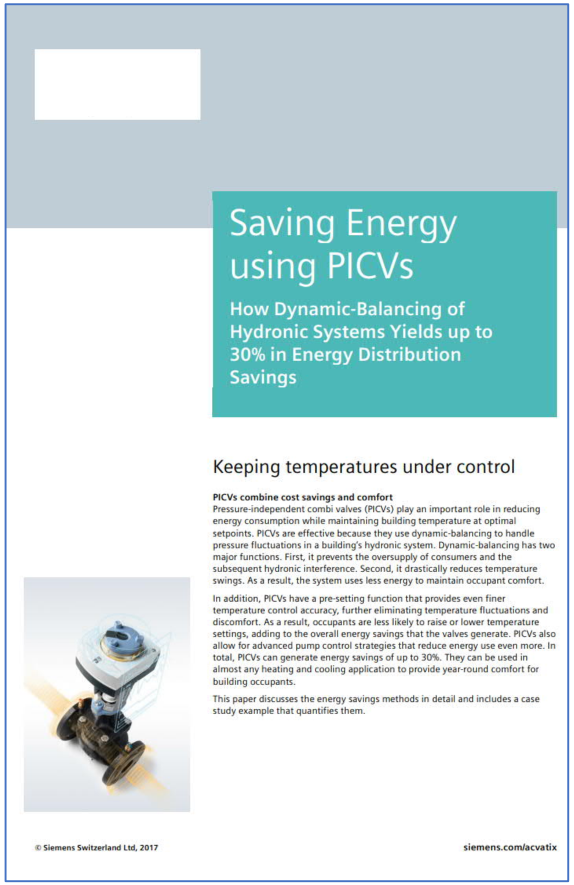
Situation with PICV



Results:

- Flow limited to 100%
- Improved ΔT: 5 K
- Chiller quite efficient
- Saved up to 30% energy

Energy saving considerations



Saving Energy using PICVs

How Dynamic-Balancing of Hydronic Systems Yields up to 30% in Energy Distribution Savings

Keeping temperatures under control

PICVs combine cost savings and comfort
Pressure-independent combi valves (PICVs) play an important role in reducing energy consumption while maintaining building temperature at optimal setpoints. PICVs are effective because they use dynamic-balancing to handle pressure fluctuations in a building's hydronic system. Dynamic-balancing has two major functions. First, it prevents the oversupply of consumers and the subsequent hydronic interference. Second, it drastically reduces temperature swings. As a result, the system uses less energy to maintain occupant comfort.

In addition, PICVs have a pre-setting function that provides even finer temperature control accuracy, further eliminating temperature fluctuations and discomfort. As a result, occupants are less likely to raise or lower temperature settings, adding to the overall energy savings that the valves generate. PICVs also allow for advanced pump control strategies that reduce energy use even more. In total, PICVs can generate energy savings of up to 30%. They can be used in almost any heating and cooling application to provide year-round comfort for building occupants.

This paper discusses the energy savings methods in detail and includes a case study example that quantifies them.

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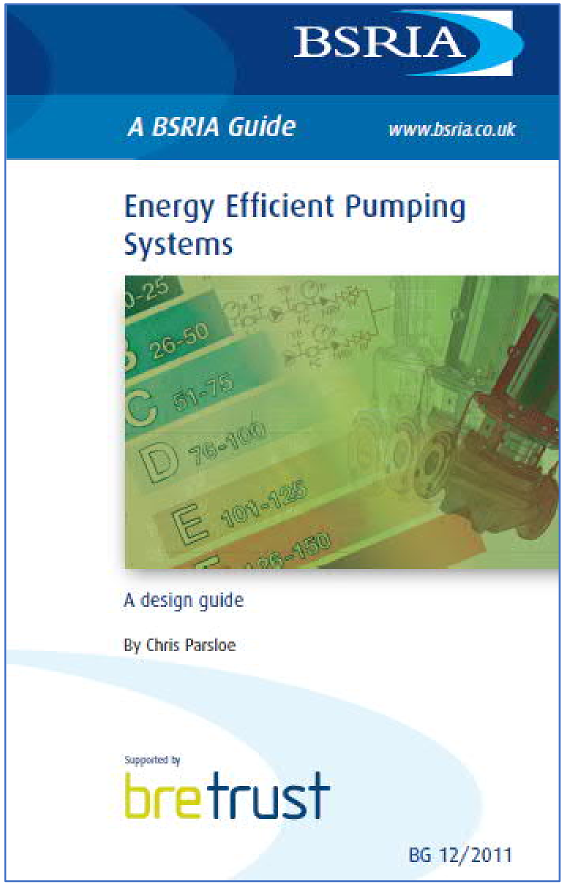


BSRIA

A BSRIA Guide

www.bsria.co.uk

Energy Efficient Pumping Systems

A design guide

By Chris Parsloe

Supported by bretrust

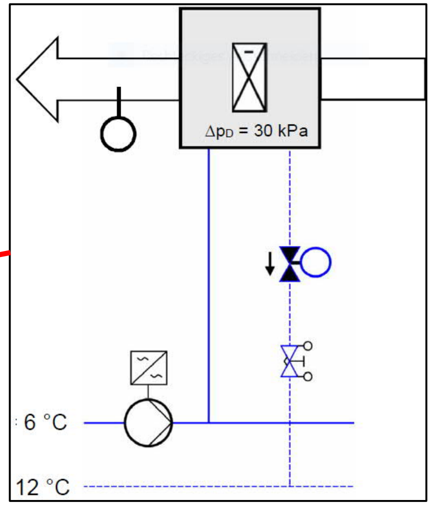
BG 12/2011

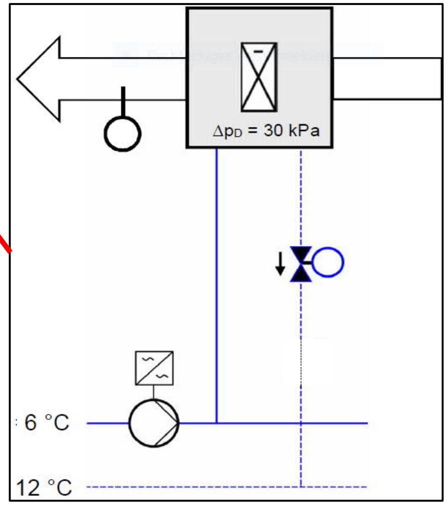
30%

Energy saving considerations

Figure 11: Alternative valve and pump control design solutions

Layout	Constant flow	Variable flow	
	A	B	C
L1 - Single branch flow return	• Four port control valves on terminal branches. • No DPCVs or PICVs.	• Two port control valves on terminal branches • Single DPCV on main branch from riser.	• PICVs on all terminal branches.
L2 - Split branch flow return layout			
L3 - Split branch reverse return layout		• Two port control valves on terminal branches. • Differential pressure sensor across the first terminal branch to control pump speed. • No DPCVs or PICVs.	
L4 - Looped reverse return layout			
L5 - Single flow return layout feeding valve modules		• Two port control valves on terminal branches. • DPCVs in modules	





Courtesy BSRIA Limited

Energy saving considerations

Figure 2: Constant pressure pump speed control

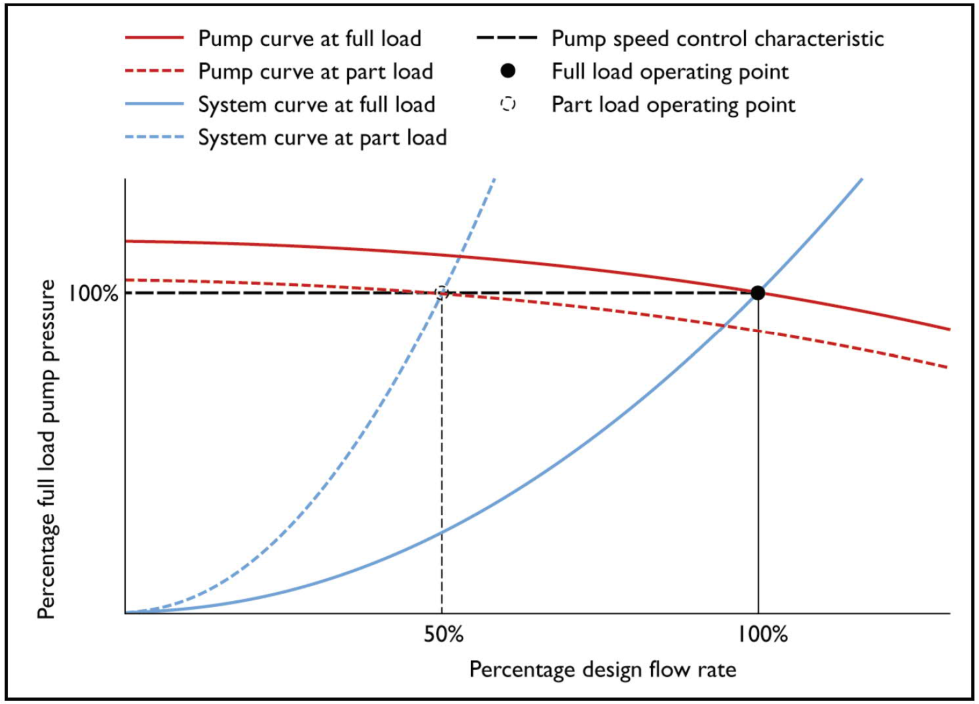
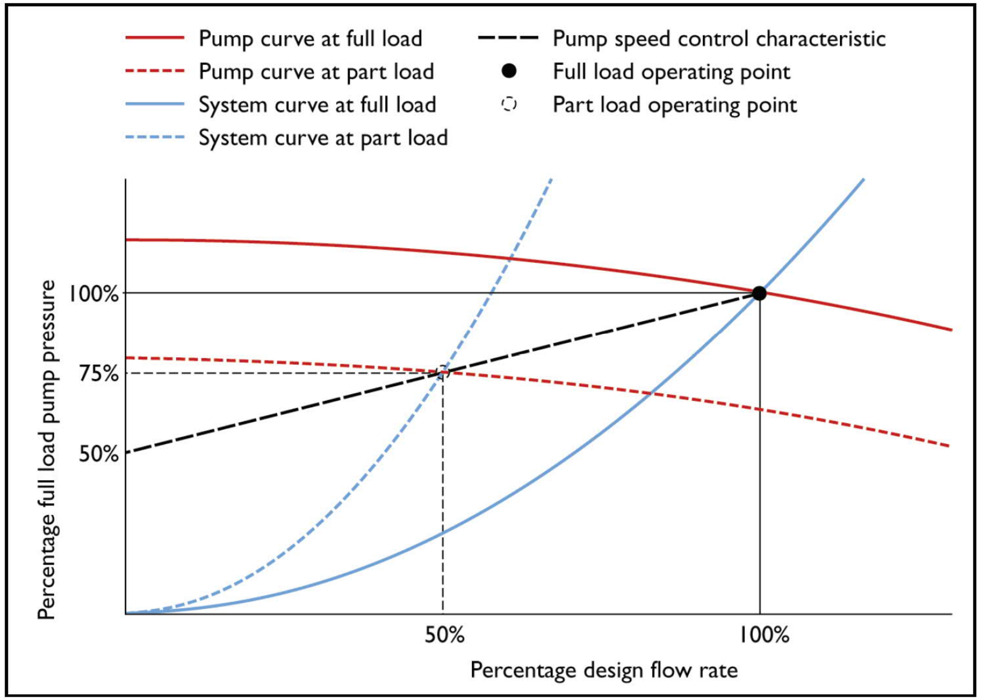


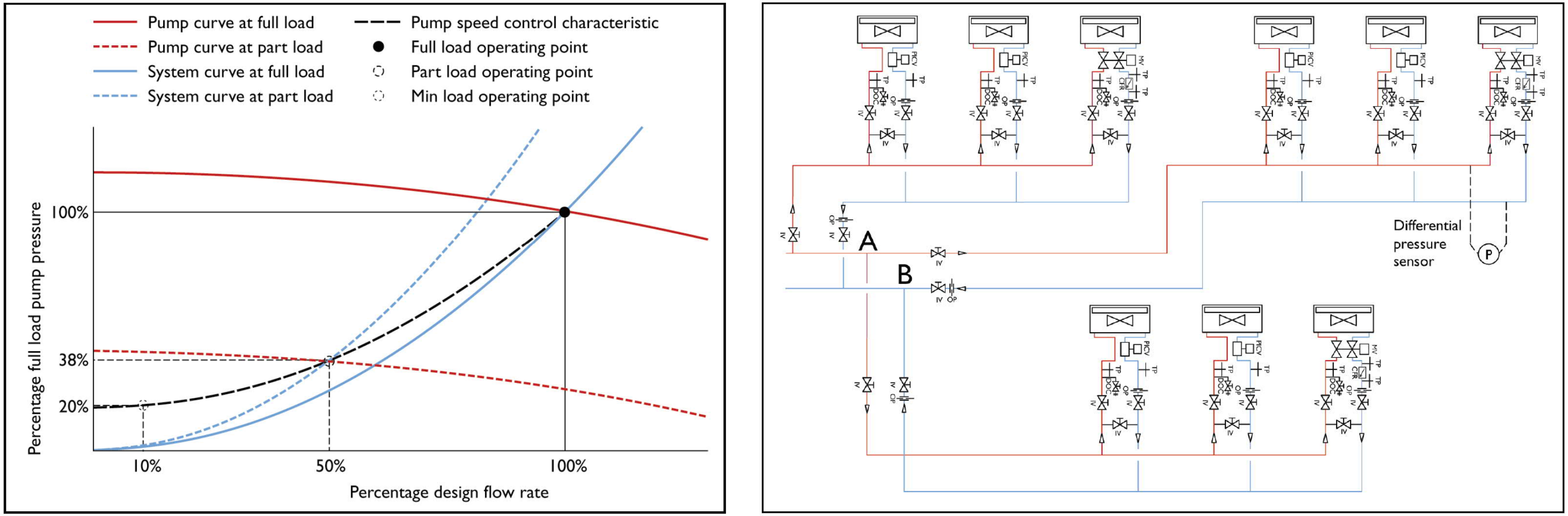
Figure 3: Proportional pump speed control



Courtesy BSRIA Limited

Energy saving considerations

Figure 4: Remote sensor pump speed control



Courtesy BSRIA Limited

Energy saving considerations

Figure 12: Comparative pump energy consumption for alternative pipe sy[illegible]esign solutions

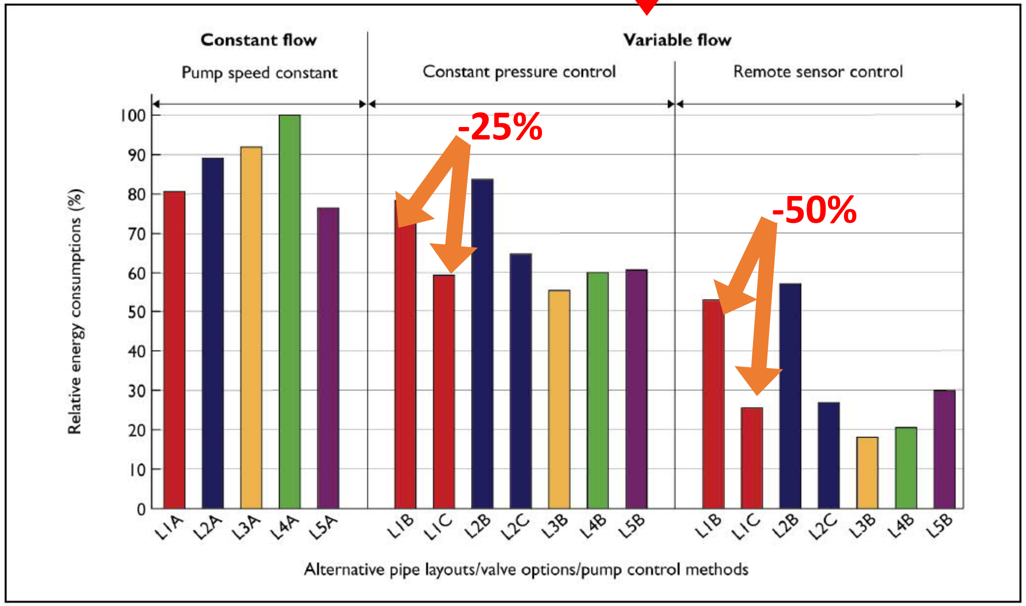
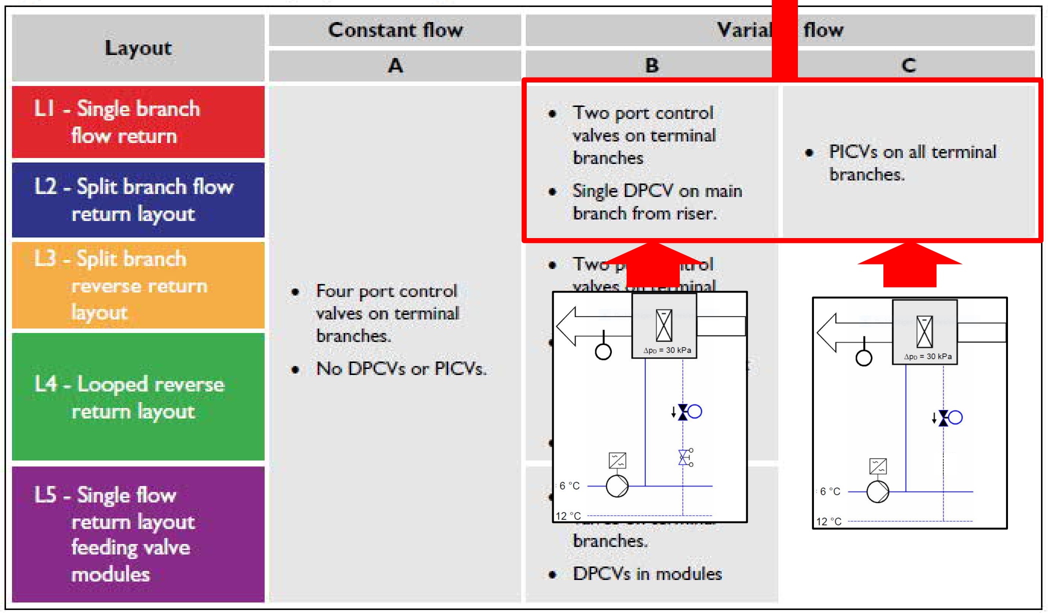


Figure 11: Alternative valve and pump control design solutions

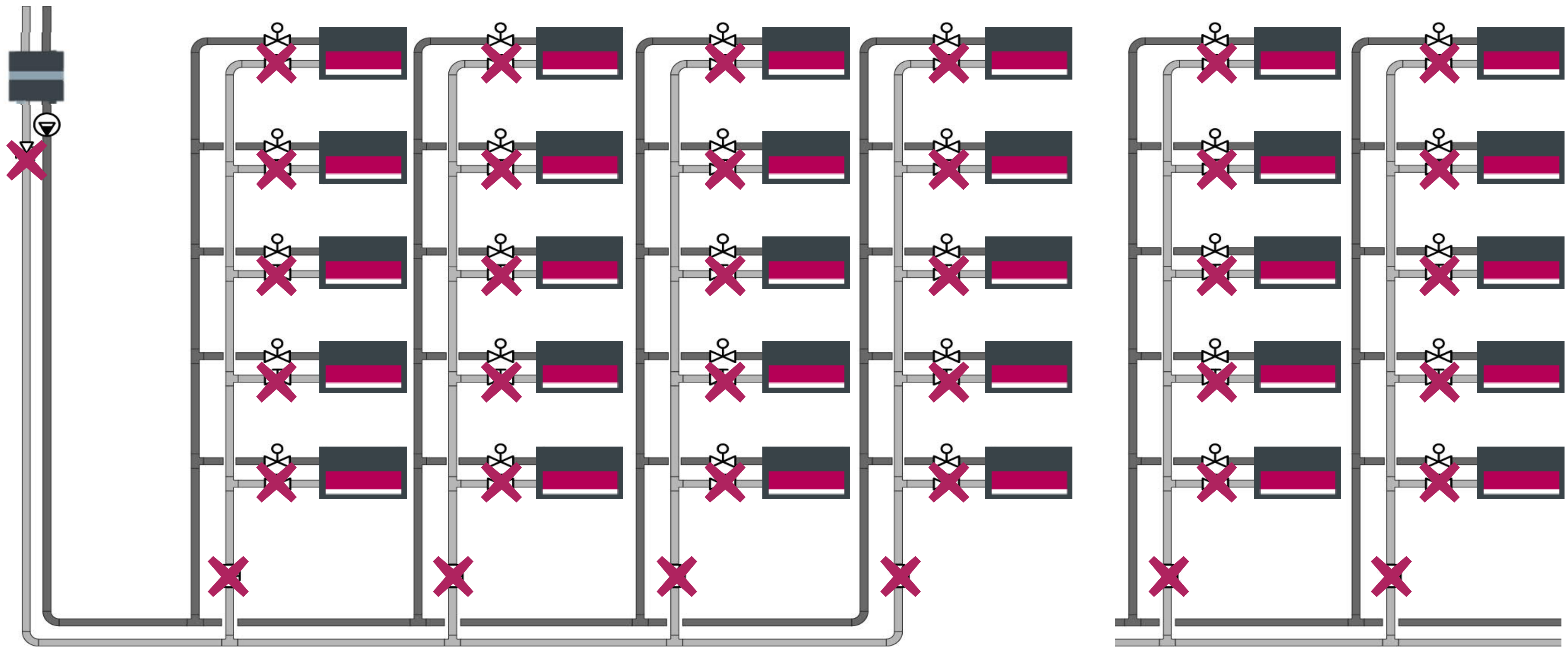


Layout	Constant flow A	Variable flow B	Variable flow C
L1 - Single branch flow return	• Four port control valves on terminal branches. • No DPCVs or PICVs.	• Two port control valves on terminal branches • Single DPCV on main branch from riser.	• PICVs on all terminal branches.
L2 - Split branch flow return layout			
L3 - Split branch reverse return layout		• Two p[illegible]trol valves on terminal [illegible]	
L4 - Looped reverse return layout			
L5 - Single flow return layout feeding valve modules		[illegible] branches. • DPCVs in modules	

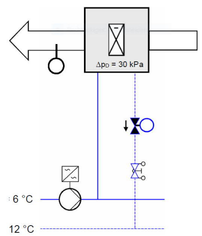
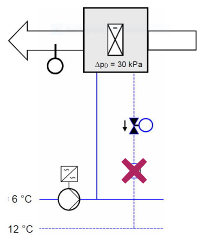
Courtesy BSRIA Limited

Cost of a PICV

From 67 valves down to 30 PICV

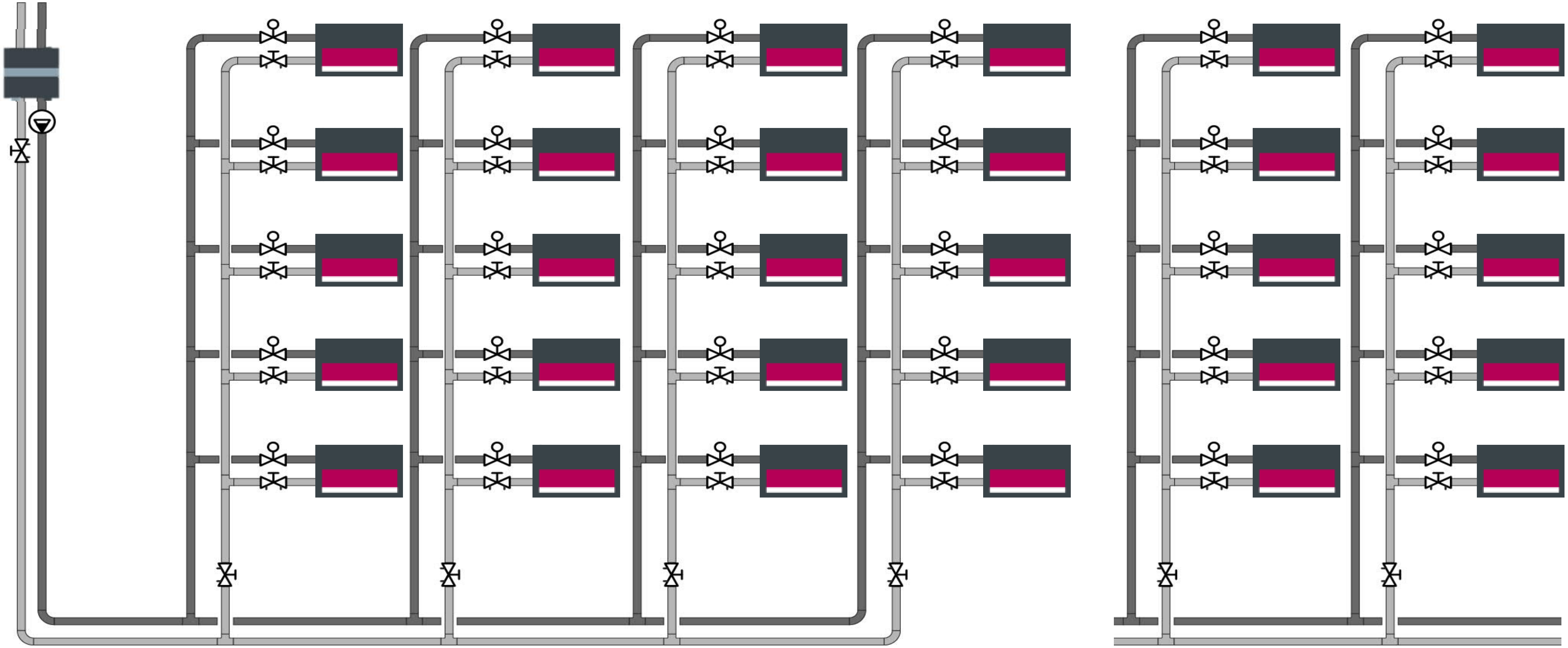


Valves cost in a project → Overall picture

	Static Balancing	Dynamic Balancing
# Units (E.g. with DN15)	500	500
Product Cost (Valves/Actuator)	Tot = 100% 	Tot = 86% 
Installation and commissioning	Install = 1h Commissioning = 1h € 60,000	Install = 0.5h Commissioning = 0.5h € 30,000
Total Cost of Installation	**€ 157'500**	**€ 114'000 (-28%)**

Potential with Intelligent Valve solution

Hydronic distribution system
Flow under control thanks to PICV



Intelligent Valve Solutions – Continuous optimization without effort

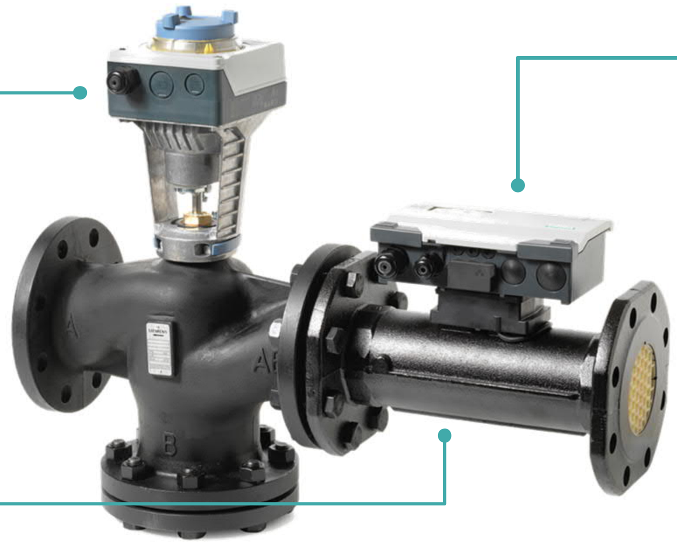
High-resolution actuator

Control valve

Ultrasonic flow sensor

Paired temperature sensors for flow and return

Controller box



Building Automation Controllers

Building Management System

Cloud

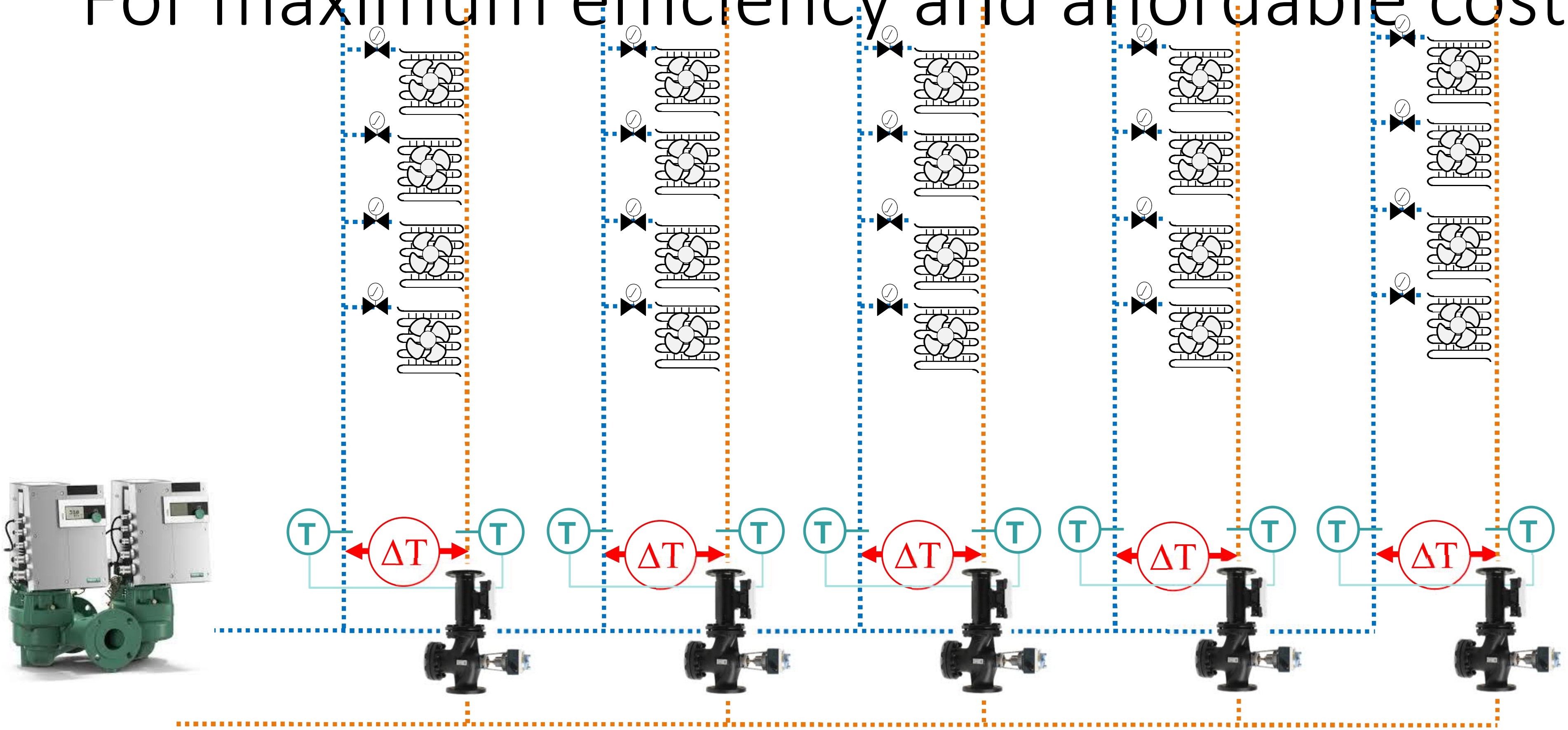
Mobile App

Local Troubleshoot

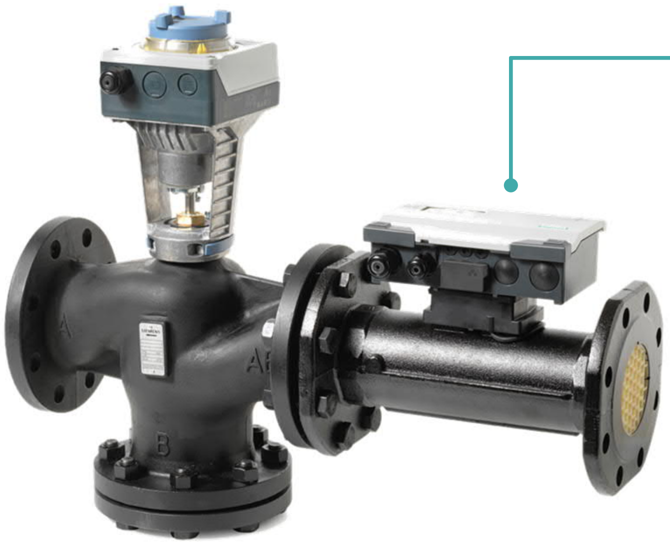
Comparison of PICV vs. Intelligent Valve

PICV	Intelligent Valve
Fast acting – high depta P	Moderate acting – moderate delta P
Local presetting	Local and remote presetting
	Real time flow / temperature / power measurment
	Power Limitation/Control
	Delta T Limitation
	Optimization Algorithems
	Network integration of all these values
	Local and remote alarming

Combine PICV's with Intelligent Valve For maximum efficiency and affordable cost



Intelligent Valve Solution – Continuous optimization without effort



Controller box

Dynamic flow control

Energy monitoring

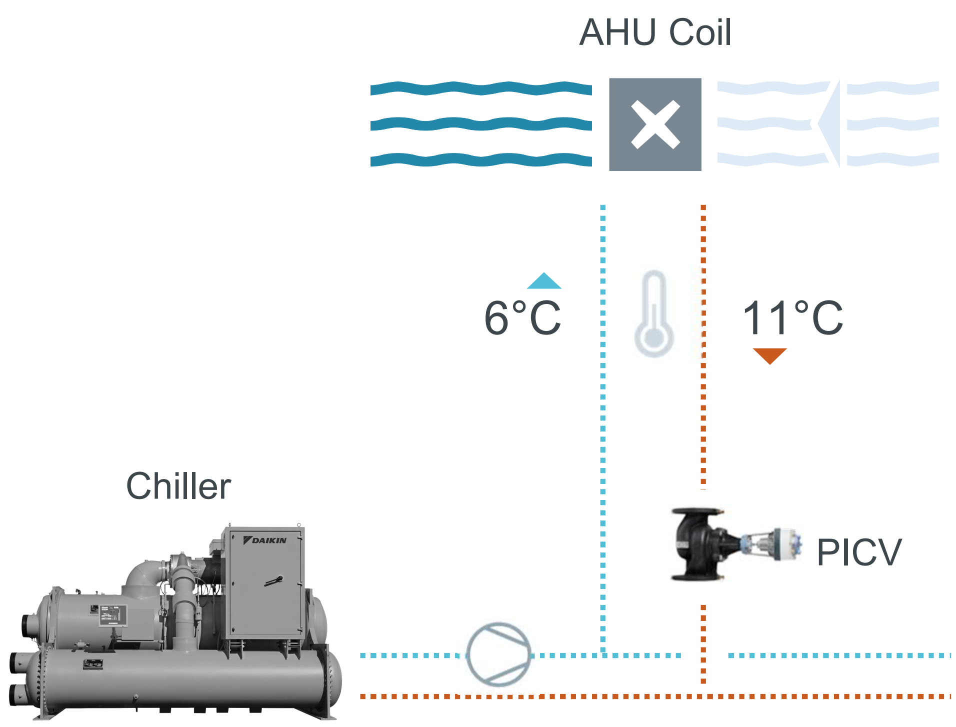
Heat exchanger optimization

Think

Act

Communicate

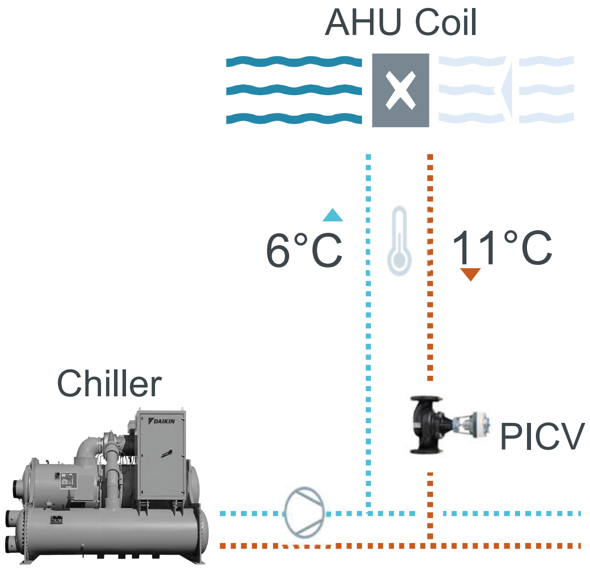
Intelligent Valve Solution
Situation with PICV

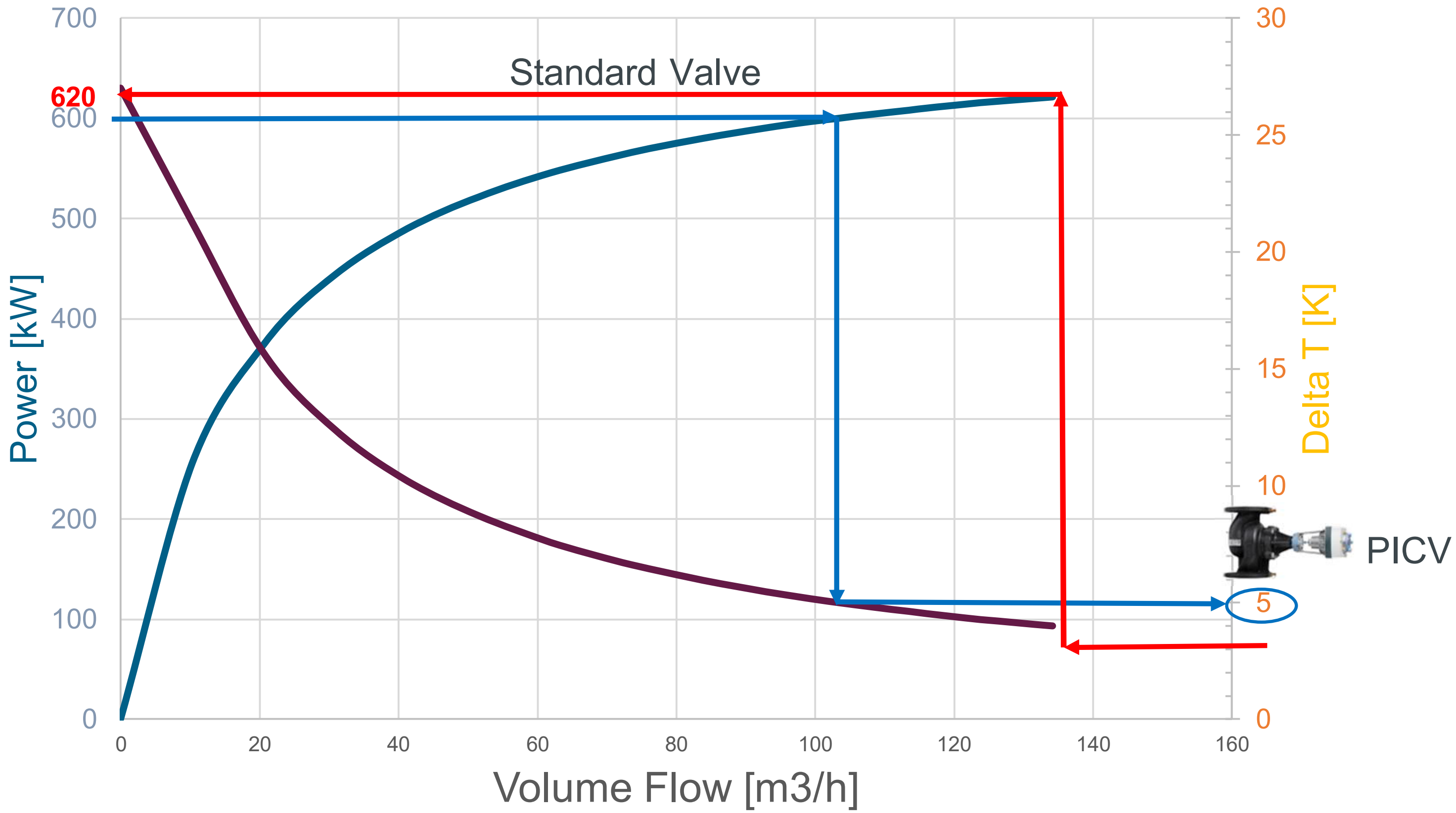


Results:

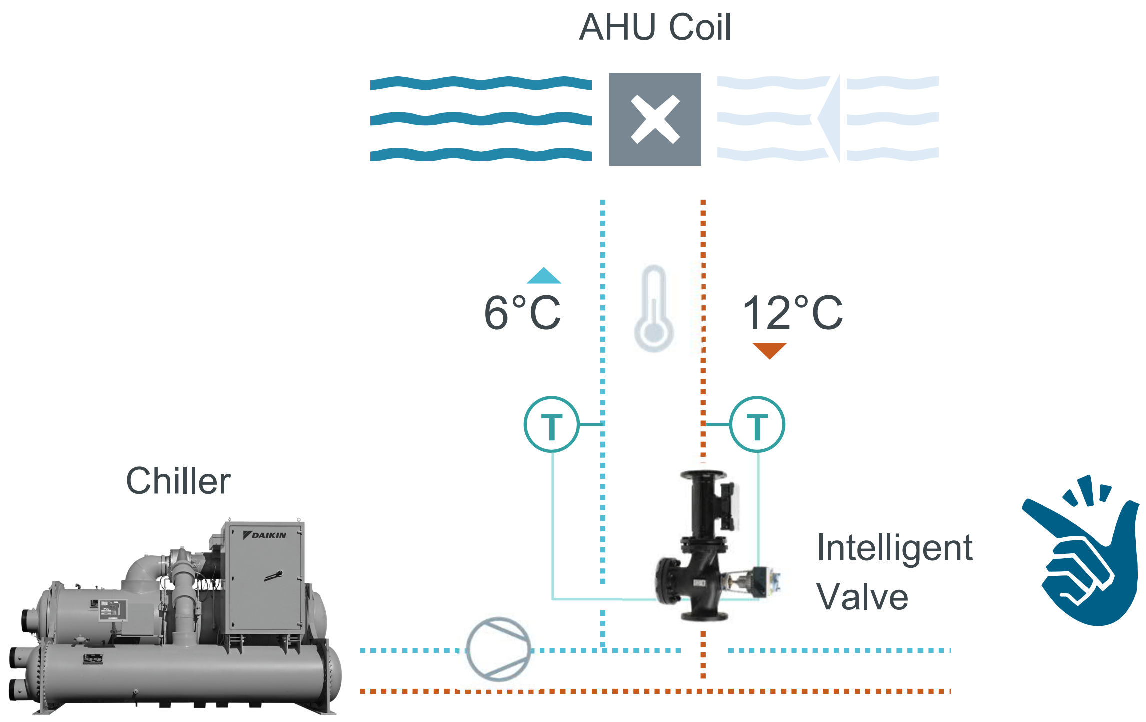
- Flow limited to 100%
- Improved ΔT: 5 K
- Chiller quite efficient
- Saved up to 30% energy

Intelligent Valve Solution
Situation with PICV





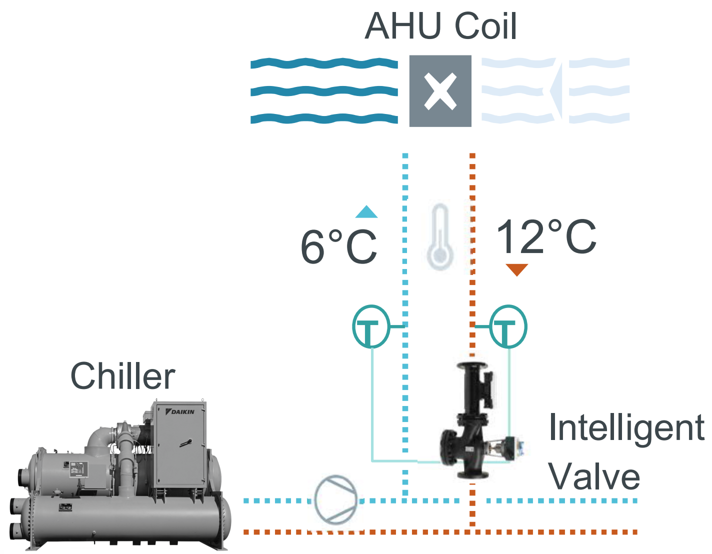
Situation with Intelligent Valve

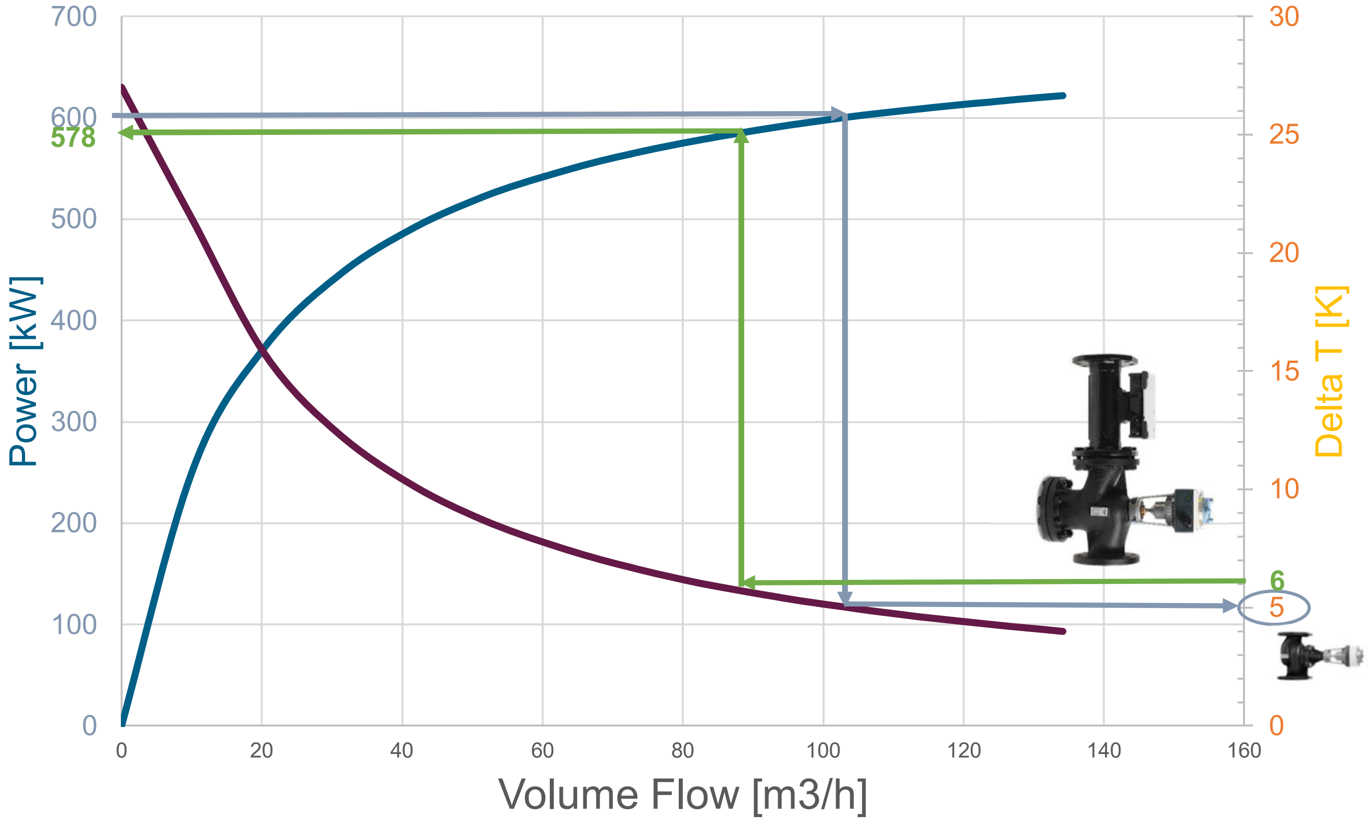


Results:

- Seeks optimal ΔT: flow limited to 80%
- Maximized ΔT: 6 K
- Chiller efficient
- Saved 7% energy in addition to PICV

Intelligent Valve Solution
Situation with intelligent Solution





That is nice, but it also means a higher investment for me!

How does my ROI look for “energy costs savings”?

Building proxy information based on information from a real project.

Our building proxy

- Office complex to be refurnished

- 20 Intelligent Valves in Distribution:
  - 4 AHUs (8 Intelligent Valves)
  - 3 distribution bars (12 Intelligent Valves)
- 500 PICVs in 500 rooms

- “Build and use” (owner = tenant) and therefore focus on
  - Hydronic balancing
  - Energy optimization
  - Flow transparency and remote operation

That is nice, but it also means a higher investment for me!

How does my ROI look for "energy costs savings"?

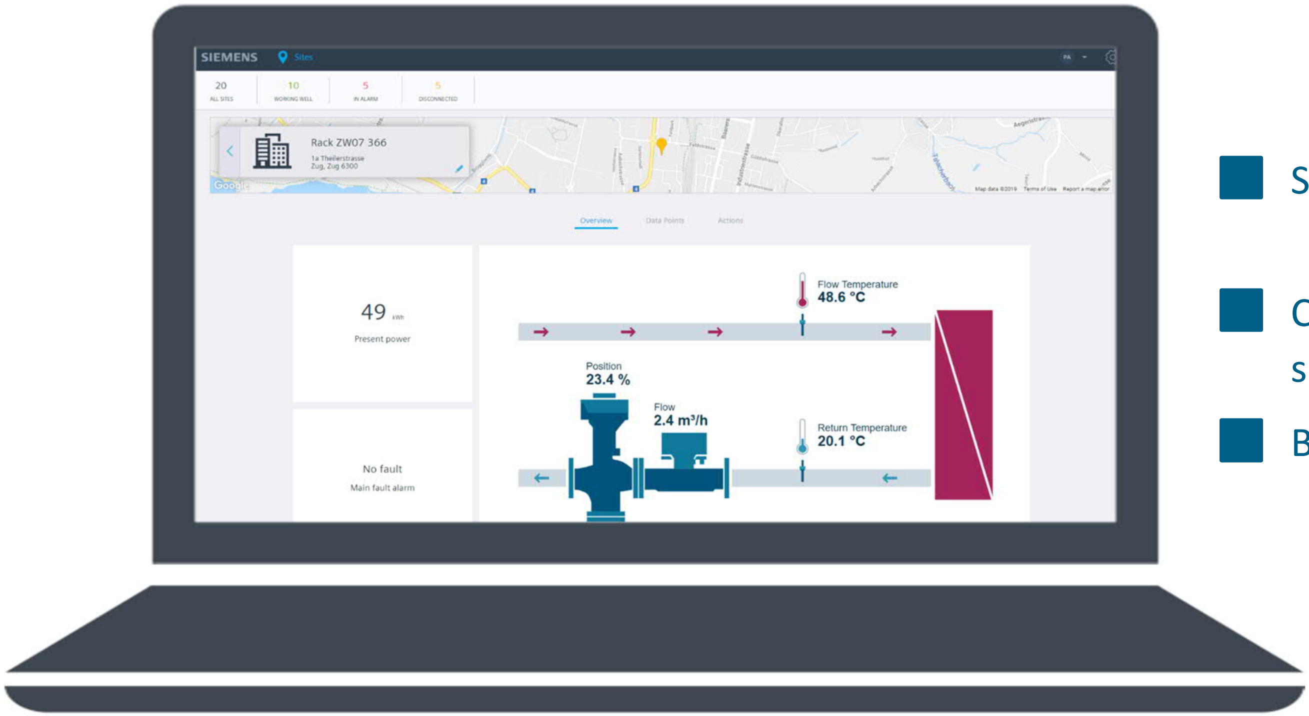
Energy savings are calculated by our application experts.

Investment		Saving	
Typical invest 20 **PICVs** (DN15-100)	€8,950	Typical yearly HVAC **energy consumption**	980 MWh
		Typical **energy cost**	€100/MWh
Typical invest 20 **Intelligent Valves** (DN15 – 100)	€16,500	Typical yearly HVAC **energy spending**	€98,000
		Average additional **relative energy saving** vs. PICV (in %)	~7%
Typical **Delta**	€7,550	Estimated **absolute yearly energy saving** vs. PICV	€6,860

Break even ~ 13 month

Creating connectivity for existing and new buildings

See what matters for your consumers



- See what matters with a dashboard
- Clear understanding of application and relevant sensor readings
- Be aware of any alarms send by device

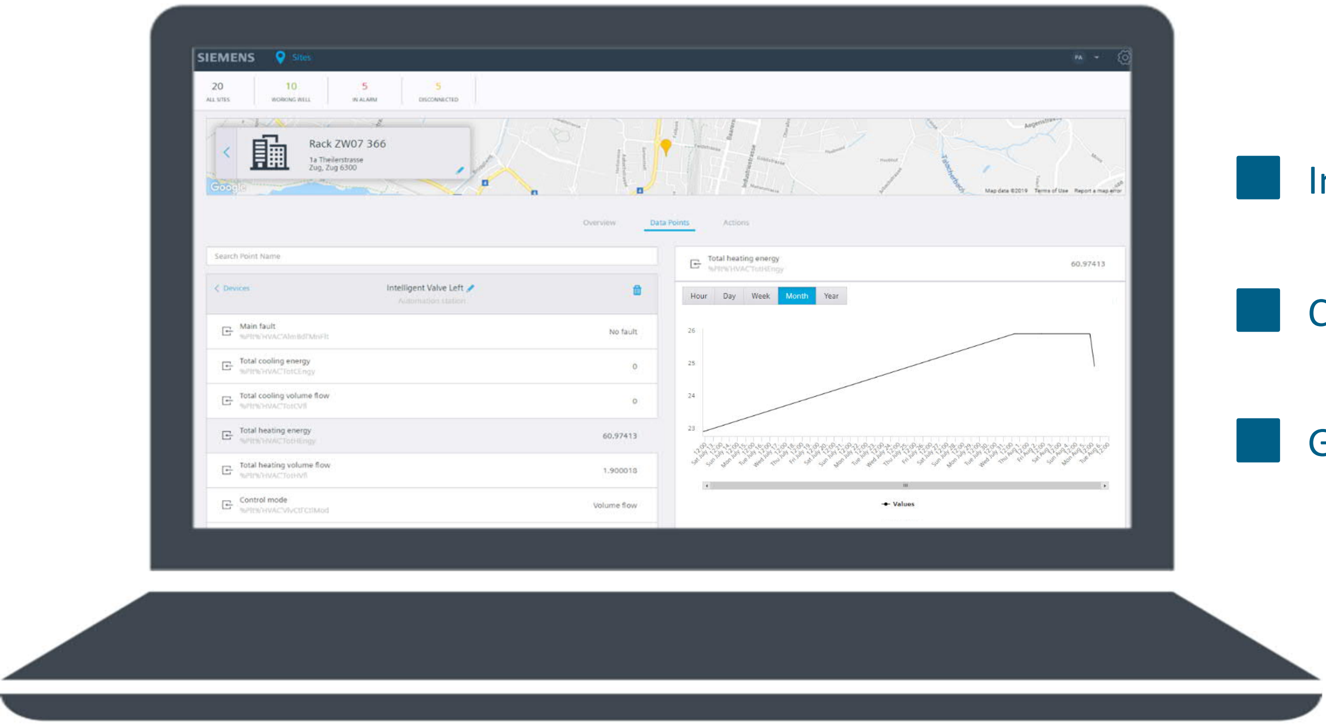
Energy monitoring

Hourly break down of energy data and report

- Hourly break down of total flow and energy data
- Self-adaptive dashboard based on cooling and heating mode
- Generate energy report

High energy efficiency

Comprehensive data history and remote operation



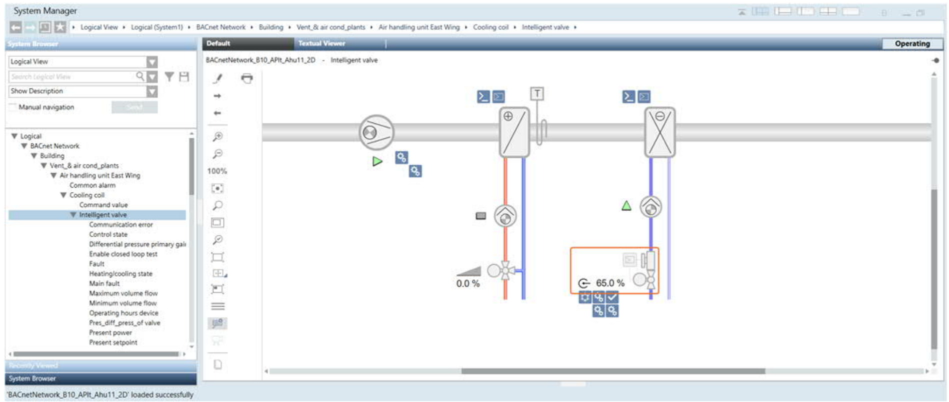
- Investigate data history for data points
- Change parameters remotely with no effort
- Generate data point report

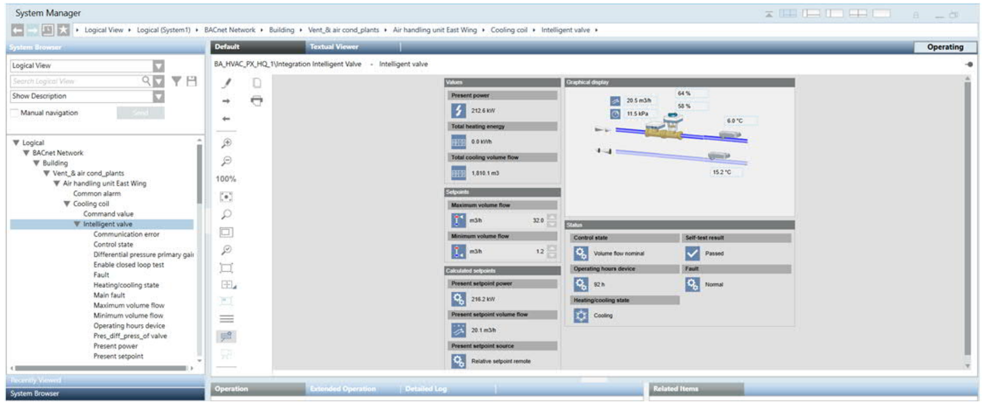
Always full transparency

Increase transparency – on every system level

- **Use case: Monitor current state with Plant and Device Graphics**

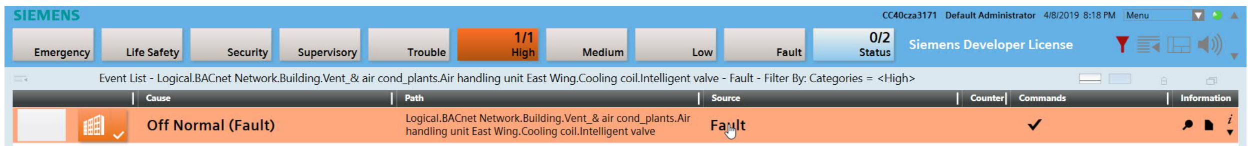
  (View and operate your Intelligent Valve(s) in your facility) :

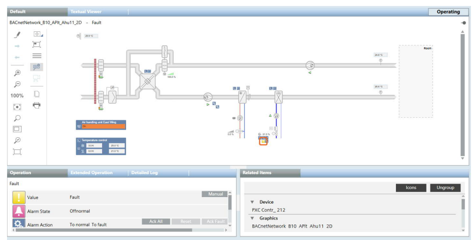




- **Use case: Troubleshoot on management level**

  (Detect and locate malfunctions early and efficiently) :





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THANK YOU!
Q&A

George Voulvoutzis
george.voulvoutzis@siemens.com