CONTROLS AND COMMUNICATION IN COMMERCIAL BUILDINGS

APPLICATION GUIDE

be
think
innovate

PREFACE

It is estimated that people in the “modern” world spend up to 90% of their lifetime inside buildings. They live, learn, work, get treated, spend their spare-time and do many other things in buildings.

But what makes buildings so interesting for us to stay in?
Buildings protect us and our belongings from many influences e.g. wind, rain, heat, cold and they give us a feeling of security.

Nevertheless, the ever-changing outside conditions still have an influence on the inside conditions. Without any action the inside temperature will sooner or later equal the outside temperature. The building’s enclosure serves as a buffer and leads to a delay before the inside conditions equal the outside conditions. This delay depends mainly on the thickness, the insulation and the leakages of the building’s enclosure which can come from walls, doors, windows and roofs.
As stated before, we stay in buildings to be protected from the changing outside conditions.
And it is common knowledge that there is a temperature range that we consider “comfortable”. This “comfort-zone” helps us to feel well and to achieve the highest productivity.
But keeping the inside conditions within the “comfort-zone” requires energy.
And as energy is a precious good, the goal is to use as little energy as possible. In other words to be as energy-efficient as possible.
And this is why we need controls in buildings.

Best regards

Grundfos Building Services,
Applications Support

INTRODUCTION

When talking about controls in CBS (Commercial Building Services) applications we tend to use different phrases that describe the same functionality. These phrases are mainly:

- Building Management System (BMS)
- Building Automation System (BAS)
- Building Controls

These phrases often go along with the question:

How do we integrate into the Management system?

But are these phrases really interchangeable? Do they describe the same?

Let's take a closer look at the different systems.

Building Automation Systems

Building Automation Systems are used to operate plants like:

- Air-handling units
- Chillers
- Boilers
- Heating
- Chilled water systems

These plants should run optimized, using the least energy possible, while still creating a comfortable environment in the building. To achieve this integrated control, loops are used, set-points are shifted and plants are switched on and off using time-switch programs or "schedulers". All this is done automatically, once all the relevant parameters as set-points, scheduler entries, etc. are entered in the system.

Pump control with wireless device

Building Management Systems

Building management systems are used for much more than building automation systems. Their main purpose is to interact with and monitor the different trades in a building or campus such as:

- HVAC installations
- Fire protection systems
- Surveillance systems
- Alarm systems
- Transportation devices (e.g. lifts)
- Water pressurising systems

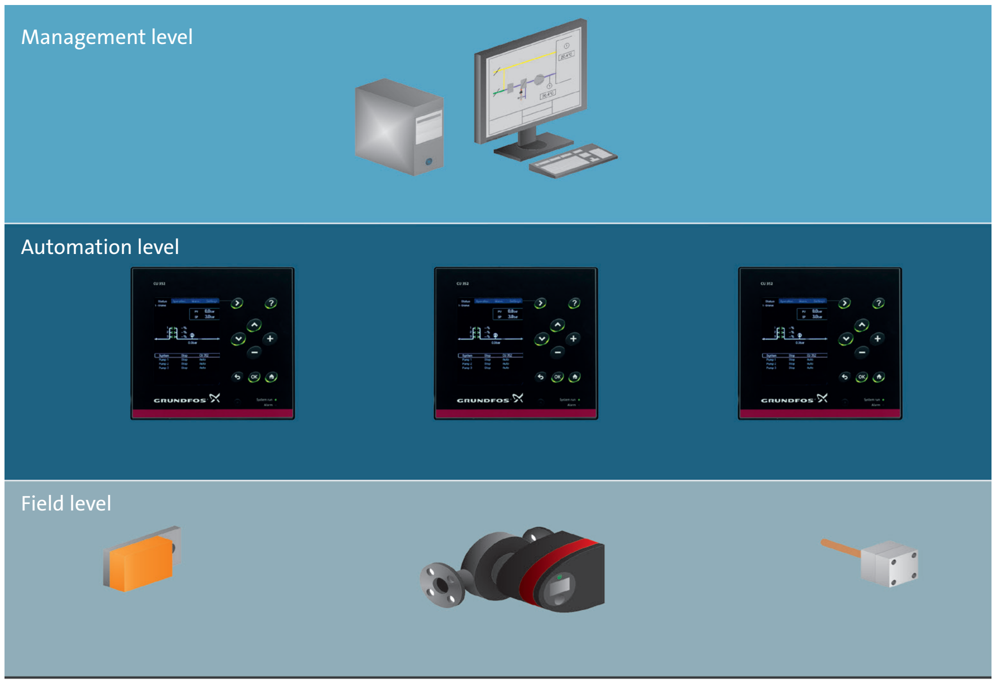
The Building Management System usually consists of one or more PCs with the software to interact with the connected Building Automation System. For easy interaction with the different plants, the BMS uses system diagram to give a fast overview of the current conditions in the plant. Other parts of the pictures could e.g. be software-switches to change set-points or turn entire plants on or off. Another very important benefit of building management systems is to archive data e.g. flow, head, power from the controlled plants on a long-term basis. This data enables the facility manager or building owner to get an overview of the buildings performance / energy use and empowers him to optimize the performance over the years. As the different values for running hours of the connected plants are also available, the so called "preventive maintenance" can be implemented, meaning that maintenance for different equipment can be done in an optimized way, reducing the driving time to and from the site.

Finally, alarms and warnings occurring in the system can be categorized and then be forwarded either immediately or during normal operation hours depending on the urgency. Usually different receivers can be defined for different trades and/or times of day.

Building Controls

Building controls summarize the different parts needed to run an installation, building or campus in an automated way. It is divided into three levels as shown in the picture below.
The three levels are:

- Field level
- Automation level
- Management level



Overview of the different levels in controls

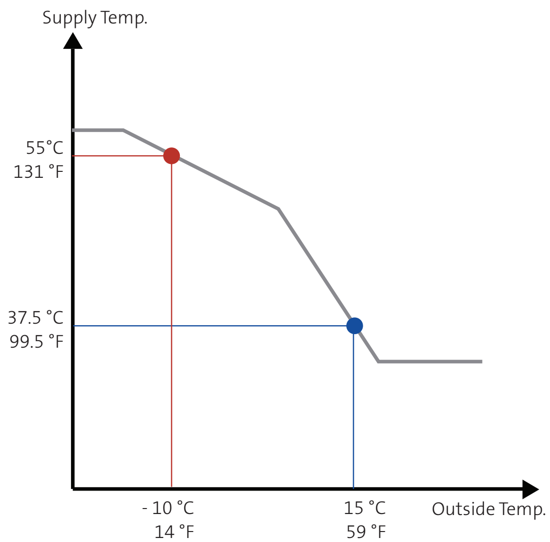
Field Level
This level contains all the devices needed to interact with the installation. These devices are mainly sensors and actuators. Other devices at this level are safety-switches and also pumps and variable speed drives.
From a controls perspective, they are treated as simple devices without any intelligence.

Automation Level
This level is probably the most important one seen from the controls perspective. It contains all the controllers to fulfill the needs of the whole installation. The devices from the Field Level are connected to the controllers or automation stations. The programs and/or algorithms in the controllers receive the information from the sensors, switches and devices, such as the connected pumps, process it and send the necessary signals to the actuators connected to them. Relevant information can be exchanged between the different controllers if they are connected by a common bus-system.

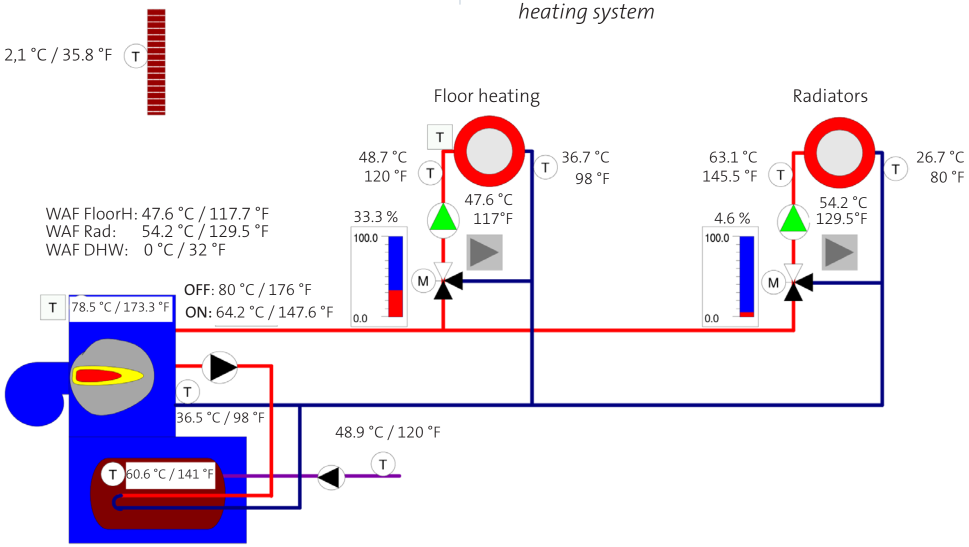
Management Level

While the Field Level and the Automation level are must-haves for a controlled system, the management level is not necessarily present in all installations. This level contains the needed hardware and software to apply visibility to the processes in the installation. This usually includes multiple pictures of the different plants, showing the relevant information like temperatures, valve positions, set-points and others.

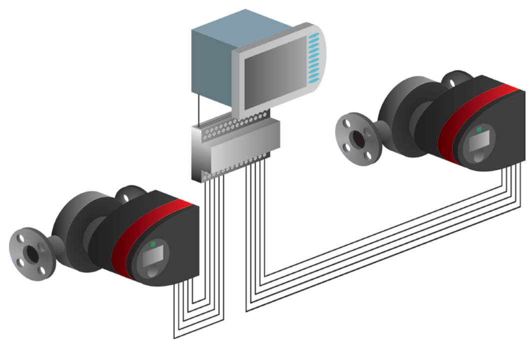
But the tasks of a building management system go much further than that. They also include archiving of data to create e.g. load profiles or to document conditions, adjustment of settings and control of units to optimize system performance, data selection to establish a “preventive maintenance” program and alarm management. The latter meaning that alarms are routed to the relevant recipients depending on e.g. their importance, the time of day or the trade they refer to.



Weather compensation curve for a low temperature heating system



Heating plant diagramme showing temperatures and valve positions



Hardwires integration with cables

INTEGRATION

To exchange information between the pumps and the management system it is necessary to create a connection between the different components. This is also referred to as “Integration” into the system. There are two common ways of integrating pumps into the system:

- Hardwired integration
- Integration via bus-communication

Hardwired Integration

The Hardwired integration requires dedicated hardware for each and every information to be exchanged between the pump and the Automation System. Standard signals are used for the exchange of information. The used signal types are:

- Digital In-/outputs
  - Floating inputs
  - Ground referenced contacts
  - Counter inputs
- Analogue In-/outputs
  - e.g. 0...10V;
  - 0(4)...20mA ;
  - Resistive sensors

Cables are used to create the point-to-point connection between the pump’s terminals and the automation system’s terminals and the automation system’s terminals.

The number of exchanged information is basically limited by the space available in the pumps connector box and by the signals available for transmission. It will, for example, be difficult to transmit the running hours from the pump to the automation system by use of the above mentioned signal types. A 0...10V signal might be sufficient at the first look, but at the second look it is difficult to scale it. 0V would probably equal 0 hours, but how many hours does 10V equal? Is it 10, 1.000, 100.000 hours or something different? And what about the accuracy of these values then? Consider the following example on the next page.

Example:

Assuming the automation system's resolution for a 0...10V signal is 1mV.

1. 10V = 10 running hours
   1V = 1 running hour
   0.001V = 0.001 running hours (approx. 3.6 seconds)

Here we can only measure with an accuracy of 3.6 seconds.

2. 10V = 1.000 running hours
   1V = 100 running hours
   0.001V = 0.1 running hours (approx. 360 seconds = 6 minutes)

Here we can only measure with an accuracy of 6 minutes.

3. 10V = 100.000 running hours
   1V = 10.000 running hours
   0.001V = 1 running hours

Here we can only measure with an accuracy of 1 hour.

Nevertheless, the hardwired integration is still very common as it is a very simple and interchangeable way of integration. Nearly every pump in the CBS market supports the commonly used information.

Description	Digital Out	Digital In	Analogue Out	Analogue In
Start/ stop	X			
Pump running		X		
Pump fault		X		
Speed setpoint (for pumps with variable speed only)			X	
Speed feedback (for pumps with variable speed only)				X

Signal types seen from the automation system perspective

Bus-communication

The bus-communication offers a much wider range of information to be exchanged between the pump and the automation system. The figure below is an example of Grundfos' CIM 300 BACnet module. This information differs from manufacturer to manufacturer, thus making the pumps not necessarily interchangeable.

Data Points							
CIM 300 BACnet MS/TP							
s = if sensor installed s* = available with sensor or TPE 2000 [1] Differential or absolute, depends on sensor [2] Not standard for Control MPC G= only for MGE model G H= only for MGE model H	**MAGNA/UPE**	**MAGNA3**	**E-Pumps** 0.25-75 KW	**CUE / E-Pumps**	**Multi-E**	**Hydro MPC / ControlMPC**	**HYDRO MULTI-B**
Control							
Operating mode	√	√	√	√	√	√	√
Setpoint	√	√	√	√	√	√	√
Control mode	√	√	√	√	H	√	
Relay control			√	√	H		
Tank filling status							√
Status							
Operating mode status	√	√	√	√	√	√	√
Control mode status	√	√	√	v	√	√	√
Feedback	√	√	√	√	√	√	√
Alarm/warning information	√	√	√	√	√	√	√
Bearing service information			G	√			
Tank filling control							√
Subpump Data							
Alarm/Status information					√	√	√
Operation time (run time)					√	√	√
Speed					H	√	√
Line current/power consumption					H	√	√
Motor temperature					H	√	√
Number of starts					H	√	√
Control pump: force to stop/auto						√	√

Data Points							
CIM 300 BACnet MS/TP							
s = if sensor installed s* = available with sensor or TPE 2000 [1] Differential or absolute, depends on sensor [2] Not standard for Control MPC G= only for MGE model G H= only for MGE model H	**MAGNA/UPE**	**MAGNA3**	**E-Pumps 0.25-75 KW**	**CUE / E-Pumps**	**Multi-E**	**Hydro MPC / ControlMPC**	**HYDRO MULTI-B**
Measured Data							
Power/energy consumption	√	√	√	√	√	√	√
Pressure (Head) [1]	√	√	s*	s*	√	√[2]	s
Flow**	√	√	s*	s*	H+s	√[2]	
Relative performance	√	√	√	√	√	√	√
Speed and frequency	√	√	√	√			
Digital input/output		√	√	√	√	√	√
Motor current		√	√	v	√		
Motor voltage			√	√			
Remote flow		s	G+s	s	H+s		
Inlet pressure [1]			G+s	s	H+s	s	s
Remote pressure [1]		s	G+s	s	H+s	s	
Level			s	s	H+s	s	s
Motor temperature			G	√			
Remote temperature		s	s	s	H+s	s	
Pump liquid temperature	√	√	G+s	s	H+s		
Bearing temperatures			H+s	s			
Auxilary sensor input			s	s	H+s		
Operation time (run time)	√	√	√	√	√	√	√
Total on time	√	√	√	√	√		
Number of starts		√	√	√			
Volume (CUE only)			H+s	s			
Amblent temperature			H+s		H+s	s	
Inlet and outlet temperatures						s	
Heat energy meter		√	H				
Outlet pressure [1]			H+		H+s	s	s
Feed tank level			H+s		H+s	s	s

Overview of datapoint in Grundfos BACnet module CIM300

All the information is exchanged using a bus-cable that is normally daisy-chained from pump to pump and finally to the automation system. Depending on the protocol used for the bus communication, the bus cable is either connected to a gateway or directly to the management systems network if the pumps run on a standard protocol. This gateway could also be a hardware module for the management system and the management systems could be BACnet, Profibus, Modbus or others.

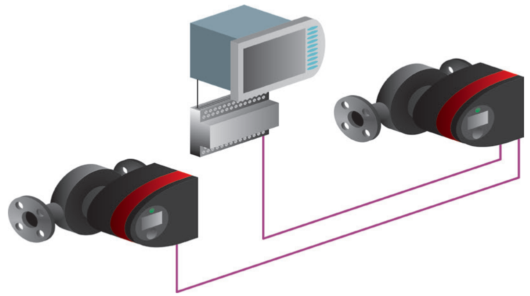
It is also very important to pay attention to the fact that bus-communication normally consists of multiple layers, defining hardware and software requirements. Although - depending on the type of communication - a manifold of layers can exist, it is imperative to at least align the basics of the bus-communication. These are bus-type (hardware) and protocol (software).

Hardware Layer

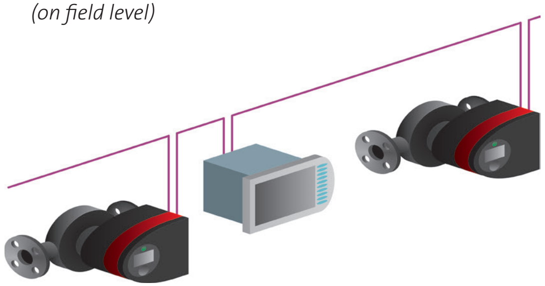
Commonly found hardware layers in CBS applications are:

- Ethernet
- LON-works
- RS485

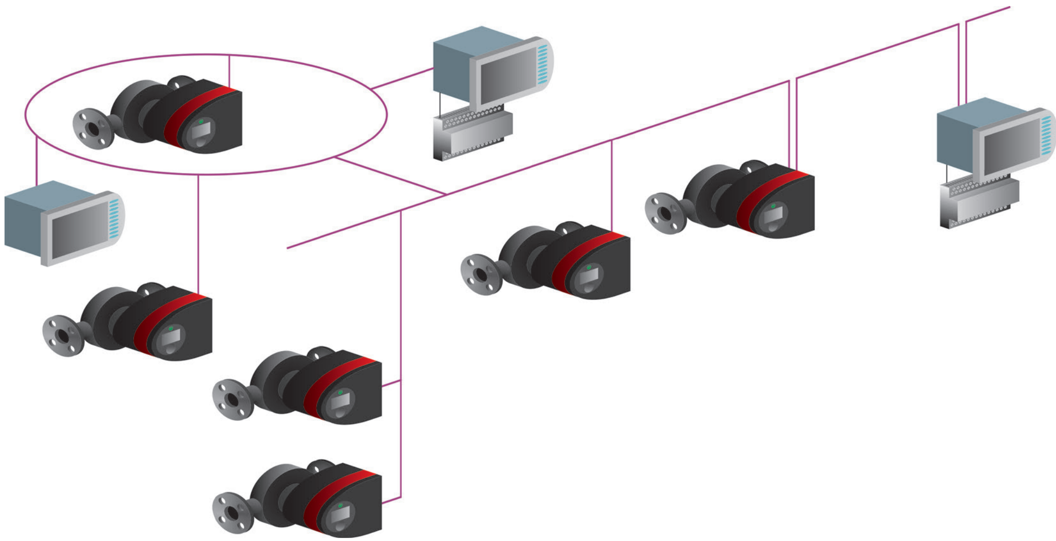
Ethernet
Networks are wide spread and known as they are basically used for all PC networks. The advantage of these networks is the speed, but using the same Ethernet



Example of a bus communication using a gateway (on field level)



Example of a bus communication directly with automation system (on automation level).



Example of a bus communication using LON-works

network for PC and automation/management systems can lead to an extensive need for coordination. Consider involving the network administrator at an early stage as he might have security concerns and have to provide you with the necessary information for each device or each device such as IP-address, subnet-mask etc. In contrary to to the above said devices in these networks, they are not daisy-chained. The installation of these networks should be done by experts in that field.

LON-works
Networks are much easier to install as they only use a simple 2-wired cable. As shown on the next page, nearly all kinds of connections are possible but every device needs a special bus-driver, the so-called Echelon-chip. In addition to that, a license fee has to be paid for each node in the network.

The RS485
Network is also using a 2-wired cable. However, the devices on the bus have to be daisy-chained and a resistor-network should be installed at both ends of the network. On the other hand no "special" hardware is required. The use of standard hardware-components is sufficient.

Software Layer

This layer basically describes how information is exchanged between the different members of the network, also referred to as the protocol used. The most commonly used protocols in CBS applications are:

- ModBus
- LON-talk
- BACnet
- Profibus

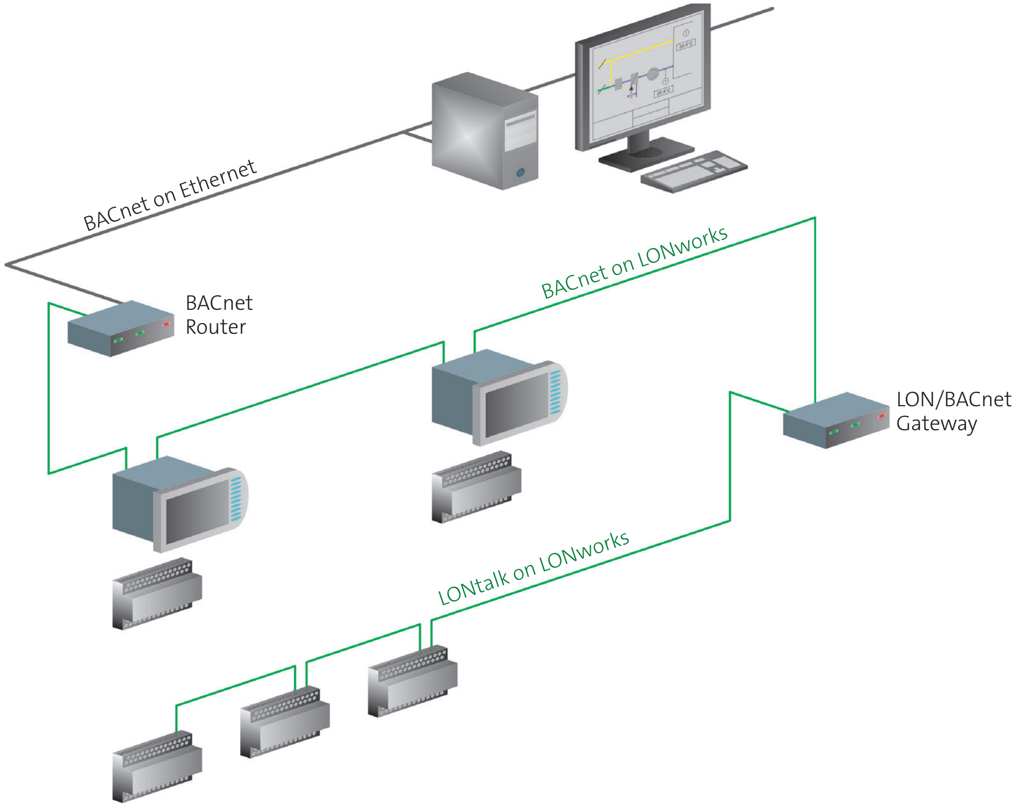
Some of these protocols require a special hardware layer, others can be run on different hardware layers. These details are shown in the table to the right.

If communication between different protocols is needed, the use of a gateway is necessary. This gateway acts as a "translator" between the different protocols. Another commonly used piece of equipment in networks is the router that is used to switch from one hardware layer to another, still using the same protocol. This could for example be a switch from "BACnet on LON" to "BACnet on Ethernet The details on this are shown on the system to the right.

However, a building management system is not always available, in which case the integration of the devices is either done only at automation level or the automation level is delivered with or integrated into the device. This is often the case when using booster-station, lifting station or even a pump.

		Hardware Layer		
		Ethernet	LON-works	RS-485
Protocol	ModBus	X		X
	LON-talk		X	
	BACnet	X	X	X
	Profibus			X

Combination of hardware and protocol.



Routers and gateways in communication

CONTROLS

The word "controls" covers a wide range of functionalities, ranging from very simple switching patterns (on/off) to extremely challenging algorithms, such as auto-adapting control loops. But even the most ambitious control tasks are achieved by the use of some basic functionalities such as logic functions, mathematical functions and control loops.

No matter how simple, all algorithms in the controllers in CBS applications are used to drive a piece of hardware to achieve the desired state of the equipment attached to them. (e.g. heating-circuit, air-handling-unit, booster, etc.). This desired state in CBS applications is defined by a given set-point for one or more of the following parameters:

- Temperature
- Pressure / differential pressure
- Flow
- Humidity
- Filling level

Control Devices

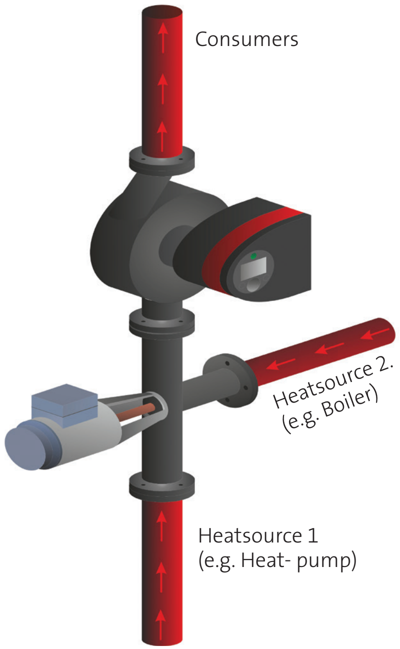
Depending on the parameter to be controlled, different devices in the installation/plants are used to achieve the desired state. In air systems the control devices are usually dampers, heating-/cooling-coils, humidifiers and fans. In water systems the devices are mainly valves and pumps.

Valves

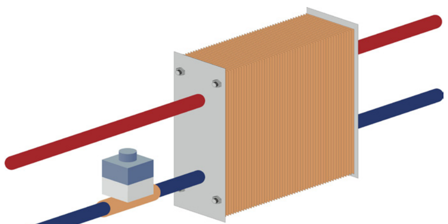
Depending on the value to be controlled, valves can be used in different ways to control an application in commercial buildings. Sometimes they are just used to change the direction of the flow. This feature is used e.g. if you have multiple heat sources like boilers and heat pumps or if you have rain-water harvesting that needs to be backed up by the regular water supply. In these cases, the use of 3-way valves is very common. They don't really fulfill controls tasks but mainly in simple switching.

Another common field of use for the valves is the adjustment of the flow. This could either be done in a fixed position (throttling valve) or by using a valve with an actuator to control the flow depending on the needs of the consumer. In this case, 2-way valves are used. This is normally used in installations equipped with heat-exchangers.

Attention:
Do not mistake throttling valves for balancing valves !
Balancing valves are used to "balance" the pressure losses in different parts of the installtion.

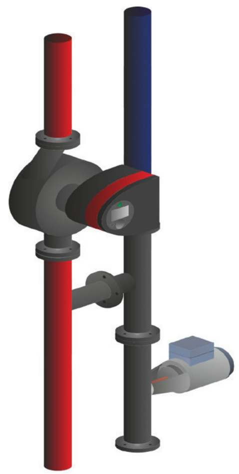


An example of a 3-way valve used for switching between different heatsources

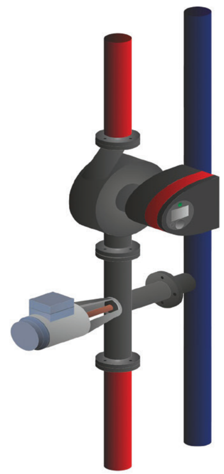


Heat exchanger, delivered power adjusted by 2-way throttling valve

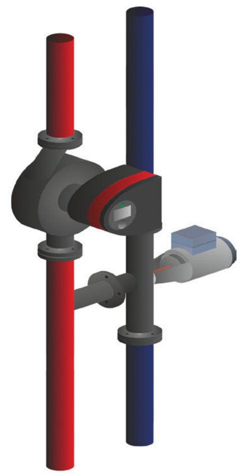
Valves can also be used to adjust the flow temperature in e.g. heating circuits. In this case, cooler return water is recirculated into the circuit and thus mixed with the hot supply water coming from the heat source. This can be done using either 2-way or 3-way valves. 3-way valves can either be installed in the supply pipe, thus working as a mixing valve or in the return pipe, then working as a diverting valve. However, not all 3-way valves are suitable for both types of installation. Especially when using them as diverting valves, you should double-check with the supplier if they are suitable for that use.



2 - way valve



3 - way valve
(mixing)



3 - way valve
(diverting)

PUMPS

Whenever the flow-adjustment in an application is needed, varible speed pumps should be considered an alternative to throttling valves. Running a pump at constant speed and then adjusting the flow by adding an additional resistance to the system is an unjustifiable waste of energy. The energy-savings potential is huge when using variable speed pumps as the affinity laws apply. These are as follows:

Insert explanation of
Q = Flow [l/s], [m³/h] or [GPM]
N_x = Speed [rpm]
H_x = Head [m] or [ft]
P_x = [W] or [Hp]

1a: Flow is proportional to speed

$$\frac{Q_1}{Q_2} = \left(\frac{N_1}{N_2}\right) \textit{ leading to } Q_2 = \frac{Q_1 \times N_2}{N_1}$$

1b: Pressure is proportional to speed squared

$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2 \textit{ leading to } H_2 = \frac{H_1}{\left(\frac{N_1}{N_2}\right)^2} \textit{ or } H_2 = \frac{H_1 \times N_2^{\,2}}{N_1^{\,2}}$$

1c: Power is proportional to speed cubed

$$\frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3 \textit{ leading to } P_2 = \frac{P_1}{\left(\frac{N_1}{N_2}\right)^3} \textit{ or } P_2 = \frac{P_1 \times N_2^{\,3}}{N_1^{\,3}}$$

Example: Effect of speed reduction on flow, head and energy consumption

Reducing the speed of a pump from 100% to 95% has the following effects:

New flow is:

$$Q_2 = \frac{1 \times 0.95}{1} = 0.95 = 95\ \%$$

New head is:

$$H_2 = \frac{1 \times 0.95^2}{1^2} = \frac{1 \times 0.9025}{1} = 0.9025 = 90.25\ \%$$

New power is:

$$P_2 = \frac{1 \times 0.95^3}{1^3} = \frac{1 \times 0.8574}{1} = 0.8574 = 85.74\ \% \text{ (Energy-savings are 14.26\%)}$$

In addition, the flow-adjustment depending on the consumers' needs is a wide field of use for speed-controlled pumps. The needed flow can differ depending on the time of day, the time of year, outside conditions, occupancy and many other factors. Using speed-controlled pumps in these applications, the savings are even bigger than in the example before. Very often, the load of the consumer is only 50% of the design load. Taking this into account, the energy-need is:

$$P_2 = \frac{1 \times 0.5^3}{1^3} = \frac{1 \times 0.125}{1} = 0.125 = 12.5\ \% \text{ (Energy-savings are 87.5\%)}$$

Attention: Do not mistake throttling for balancing
Balancing is used to "balance" the pressure losses in different parts of the installation. hrottling is used to adjust the flow to the design point or the current need of the consumer. A speed-controlled pump doesn't necessarily make balancing valves obsolete.

Control Loops

As stated earlier the control devices are used to achieve a desired state. The output signal for the control device has to be determined by some kind of algorithm in the so-called controller. The simplest algorithm is to give a fixed signal to the actuator (valve or pump). This signal could be set by a potentiometer or by setting a fixed output value in a piece of software, which is part of the controller. However, it is more common to have a changing output signal, calculated by the so-called control loops. We'll now have a look at the most frequently used control loop types.

Open Loops

Open loops are often found in industrial applications. This is due to the fact, that industrial applications often use a series of different actions. The open loop waits for an input signal to either appear or change and depending on that signal sets an output signal. The result of the action is not double checked and will have no influence on the output signal.

An example in industrial environment is the filling of bottles in an factory. A sensor will detect a bypassing bottle. Now the conveyor belt will stop and the filling valve will open for x seconds. After the time has elapsed, the belt will start again, transporting the bottle to the next station. The loop doesn't receive feedback as to whether or not the filling was successful.

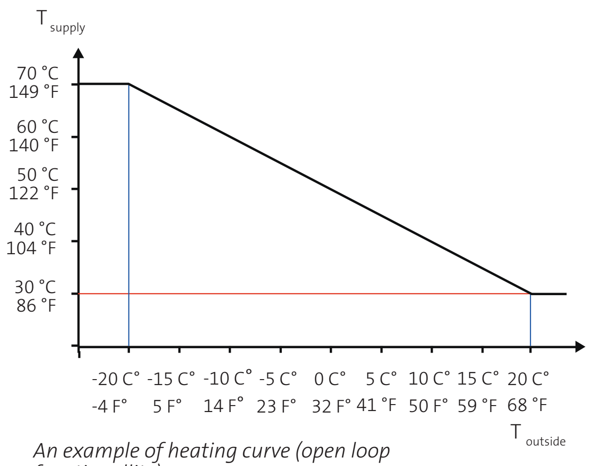
A very common use-case for open loops in HVAC applications is the outside temperature-compensation in heating circuits. The set-point for the supply temperature of the heating circuit is adjusted depending on the outside temperature. Each outside temperature is assigned exactly one supply temperature. This temperature is defined by heating-curve.

The compensation loop receives no feedback whether or not the change of the set-point was successful.

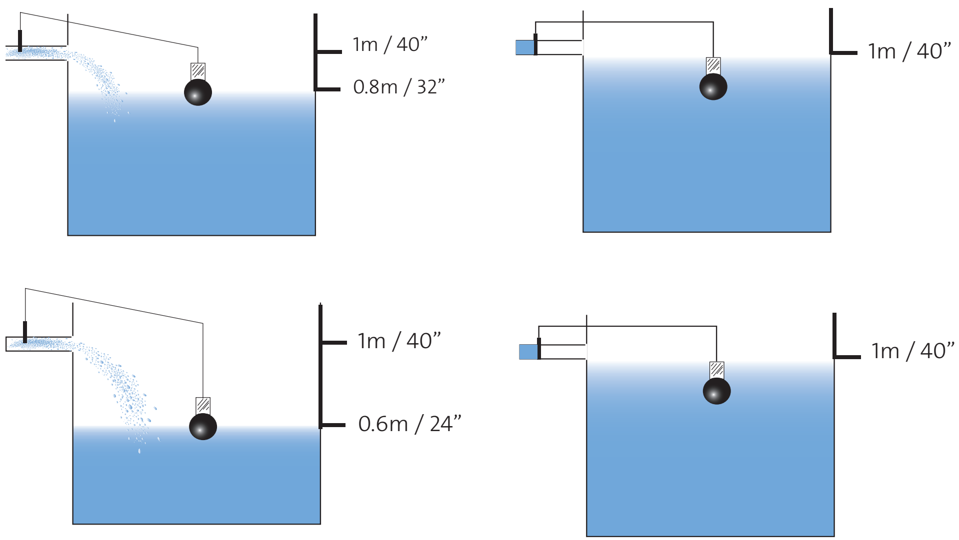
Closed Loops

Closed loops are characterized by a continuous feedback on each action. They have a set-point (fixed or variable) and try to adjust the measured signal to the set-point. They are commonly used to control e.g. the temperature, pressure or humidity in HVAC applications.

The output signal of the closed loop is changed as long as there is a deviation between set-point and measured value. When the measured value equals the set-point the output signal will remain at its level.

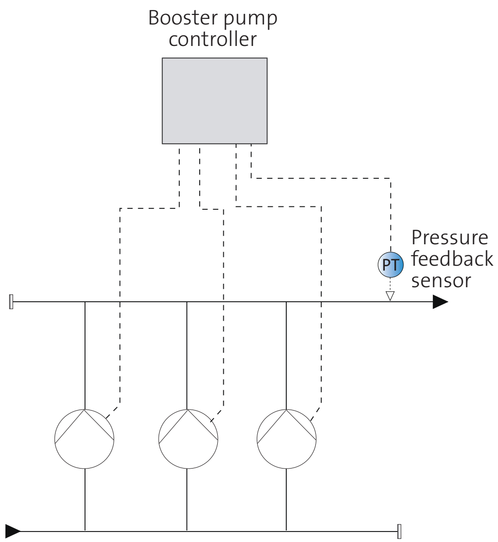


An example of heating curve (open loop functionallity)

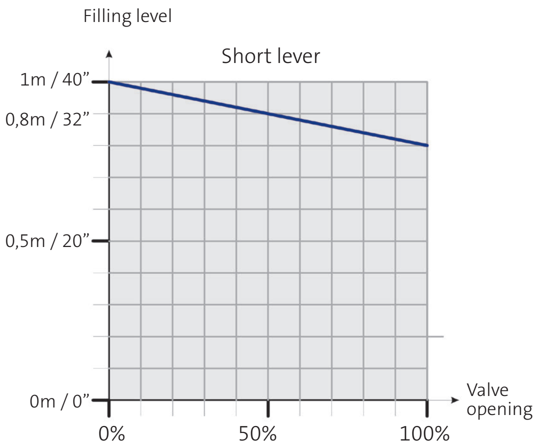


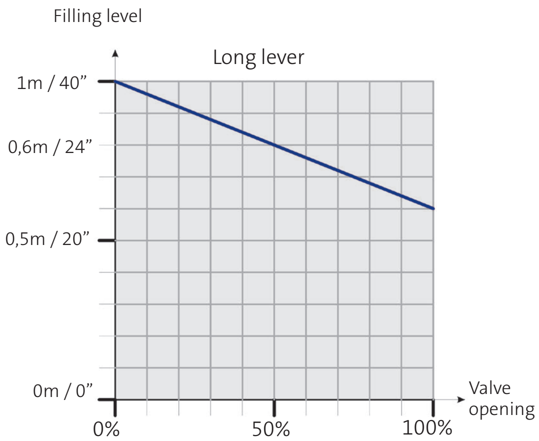
An example of a simple closed loop

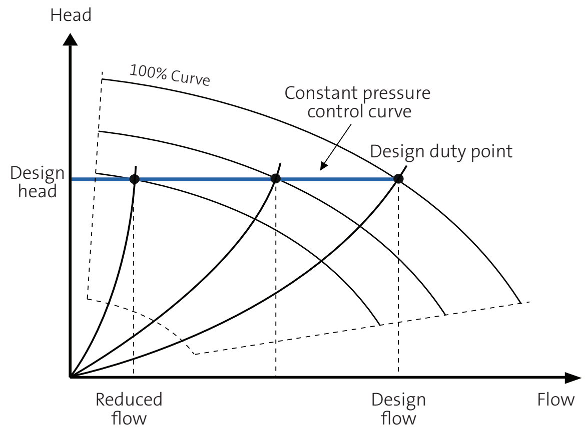
A simple example of a closed loop is the filling of a reservoir. A float lever is used as the controller. The desired filling level of the reservoir is the set-point and the floater itself supplies the feedback. The floater lever is connected to a valve that opens or closes a pipe to fill the reservoir. If the level in the reservoir drops, the floater will open the valve until the desired filling level is reached again. The relation between fill-level and opening of the valve can be seen in the figures below.
By changing the length of the lever, the filling degree between fully closed and fully opened can be adjusted.



Example of a closed loop system, water booster set







Pump QH curve with constant pressure control

Pump control modes

Modern pumps and their respective controls, either build in or as a separate controller, offer multiple control modes. Each of them has its own characteristics and is used for different purposes. In the following paragraphs we'll have a look at the most common control modes and we'll give hints on where to use them. However, additional control modes may be available or may be used for certain applications.

Constant Pressure

As the name already indicates, the main purpose of this control method is to keep a constant pressure in the system. This is mainly due to the fact that a minimum or constant pressure is required for a consumer, no matter what the flow is.
One of the most common applications for constant pressure control mode is the water boosing system. The speed variation of the pump can either be achieved by using an external Variable Frequency Drive (VFD) or by using a pump with integrated speed control. The following figure shows how constant pressure is achieved by using a variable speed pump. Reduction in the needed flow leads to a reduction in the pump speed and this ensures that the pressure is kept at constant speed.

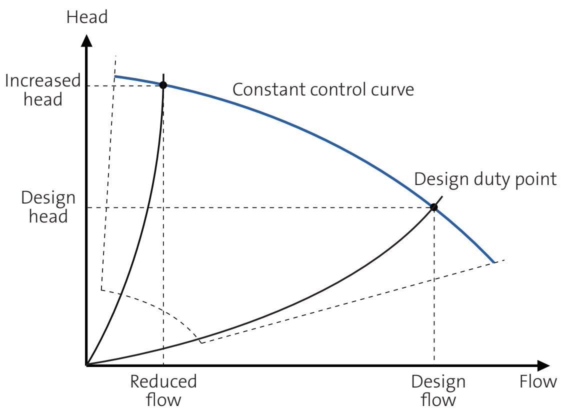
Constant Curve

In this control mode, the speed of the pump is kept constant, resulting in a fixed curve. Every needed change in flow can only be achieved by changing the resistance (i.e. the head) of the system. All duty points are placed on the pump curve. This results in increased head at reduced flow. To adjust the flow in constant curve systems, it is necessary to have a throttling device.
Constant curve mode should only be used in systems that run at design point or at least most of the time. A good example could be an industrial application, where a machine is equipped with a dedicated cooling coil. If the machine produces a constant amount of heat, the pump will always run at design point as the internal resistance of the system will not change at constant flow.

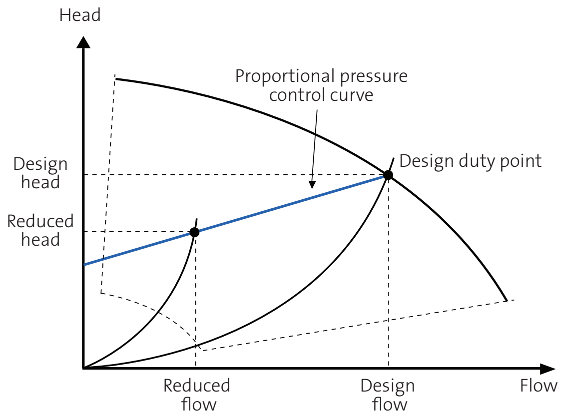
Before variable speed pumps were available, it was common to use 3 speed pumps. These allowed the pump to be operated at 3 different constant curves, but usually these curves were selected manually.

Proportional Pressure

In closed systems with multiple consumers and/or changing loads this is a very useful control mode. This control mode takes the fact into account that each hydraulic system has a system curve. The characteristics of this system curve is that the needed head decreases at reduced flow. This is mainly due to the fact that the friction losses in the pipe work are reduced at decrease flow. As we learned in the section about the “Constant curve” a fixed speed pump would create a bigger head at reduced flow. This is totally in contradiction to the system curve.



Change in head and flow in a constant curve system



System running in proportional pressure control mode

Pump control using a dedicated wireless device, IOS or Android cell phone.

Proportional pressure adapts the delivered pump head according to the flow in the system and thus achieving a better system controlability as well as a huge pump energy saving. The relation between reduced flow and head in a system running at proportional pressure control mode is seen in the figure left.

A typical application where the control mode proportional pressure is used is a two pipe radiator system, where for example radiators are equipped with thermostatic valves. In these systems the flow-rate is constantly changing and hence the head demand is changing as well.

AUTO*ADAPT*

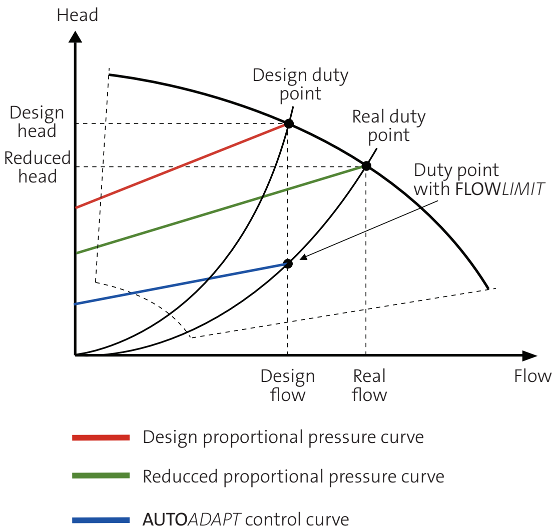
This control mode is a special variant of the proportional pressure mode. The system starts with a standard proportional pressure curve. By monitoring the behavior of the pump/system during operation the control curve is slowly adjusted to meet the “real” system curve of the system as closely as possible. As AUTO*ADAPT* is working with proportional pressure curves, everything written in the section “Proportional Pressure” also applies for AUTO*ADAPT*.
Although it might seem that AUTO*ADAPT* is the perfect weapon for all cases, it was designed to be used for variable flow in heating systems and should be used especially for them. Still there will be cases where AUTO*ADAPT* cannot set the right pump curve. In these cases the proportional pressure mode should be chosen as control mode.

FLOW*LIMIT*

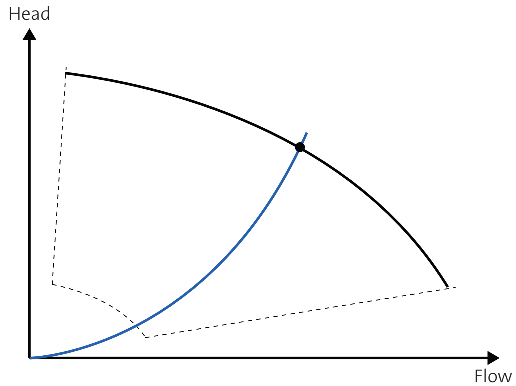
This function is used to eliminate overflow in a system that is badly balanced or not balanced at all. The maximum allowed flow has to be defined in FLOW*LIMIT*. As long as the system flow is below the maximum allowed flow, the pump will operate in the selected control mode. However, if the flow starts to exceed the maximum allowed flow defined in FLOW*LIMIT*, the pump speed is reduced and the flow is kept at the maximum allowed. This function makes it possible to avoid the throttling valve that is usually used to adjust the flow in the system. If e.g. a constant curve system is installed and the pipe work's resistances are less than at design, the flow in the system would be higher than the designed flow. Here the FLOW*LIMIT* function would just reduce the flow to the maximum defined during commissioning.
This function can be used in constant pressure mode, constant curve mode, proportional pressure mode and AUTO*ADAPT* mode. For details on the combination with Proportional pressure mode also see the section FLOW*ADAPT*.

FLOW*ADAPT*

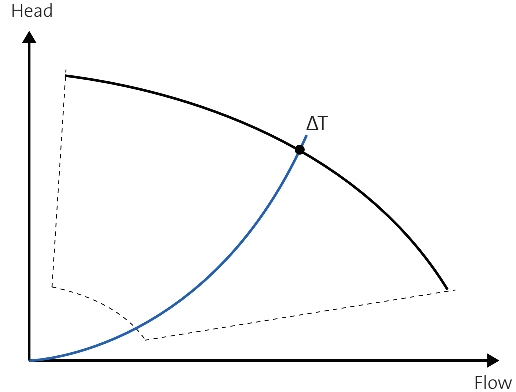
This control mode is a combination of the AUTO*ADAPT* mode and the FLOW*LIMIT* function. It combines the advantage of self-adjustment from the AUTO*ADAPT* mode with the limitation of the FLOW*LIMIT*. It radically simplifies commissioning in radiator based heating systems where the needed head is unknown and only the needed flow is known. This is often the case when replacing a pump in an existing system. In these cases the AUTO*ADAPT* part of the FLOW*ADAPT* mode adjusts the control curve whereas the FLOW*LIMIT* part takes care that the design flow is not exceeded.



Influence of FLOWLIMIT function in a poorly balanced system, where the real flow will be higher than the design flow. Here FLOWLIMIT reduces the maxuimum allowed flow to the intended design flow.



Constant temperature control mode.
The duty point travels along the system curve



Differential temperature control mode

Constant temperature control

The constant temperature control mode is maintaining the temperature that has been set on the pump by adapting the pump speed to the actual need. If the sensed temperature is increasing the pump ramps down and vice versa. The constant temperature control mode ensures that the pressure and flow in the system is just what is needed to maintain the desired water temperature. The temperature signal is based on the pumps internal temperature sensor, or an external sensor can be connected directly to the pump.

Differential temperature control

This control mode allows the pump performance to be controlled according to a differential temperature in the system. Differential temperature control is useful in for example one-pipe HVAC system. Here the heat or cooling units flow and return pipes are connected to the same main pipe. Depending on the load, only a part of the total flow passes through the individual heating or cooling unit. For example radiators or fan-coils, whereas the remaining part is by-passed. The challenge of the application: At low load situations the thermostats will close, which means that by-pass flow is increased and hence the temperature difference is narrowed. This is an undesired situation if the system is connected to a supply system that requires high temperatures to work efficiently. For example a condensing boiler or a district heating system. Furthermore this effect will amplified, if the systems is designed and operated as a constant flow system. The solution is to operate the system in differential temperature control mode. This control mode will seek to keep the desired temperature difference, by adapting the pump speed and hence the flow. If the temperature difference in a heating system is decreasing, the pump will ramp down until the desired temperature difference is restored and vice versa.
This control mode requires two temperature sensors, either the pumps internal temperature sensor together with an external sensor or two external sensors.

SUMMARY

In this booklet we have tried to shed light on the “mystery” of controls, although we have only scratched the surface of what controls is all about. Nevertheless, we hope we created some awareness about the complexity of controls and especially integration of different products into systems.

In each and every project you need to answer questions like:

- Do you integrate it into a Management System?
- If you integrate, on what level and how do you it?
- Do you need bus-communication?
- If you use bus-communication, which hardware-layer and which protocol should be used?
- Which control devices should be used (variable speed pumps, throttling valves, etc.)?
- Which control mode makes sense for the application?

Thinking about all these aspects might take some time and clarification with other stakeholders in the project will be necessary. But the energy savings and increase in comfort that can be achieved by having an optimized control-strategy and interaction between the different trades in the project make the efforts worthwhile.

Always remember:
Controlled HVAC systems (Heating, Ventilation and Air-Conditioning) should
produce comfortable conditions inside buildings by the most efficient use of energy.
And this is something we should all try to achieve.

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