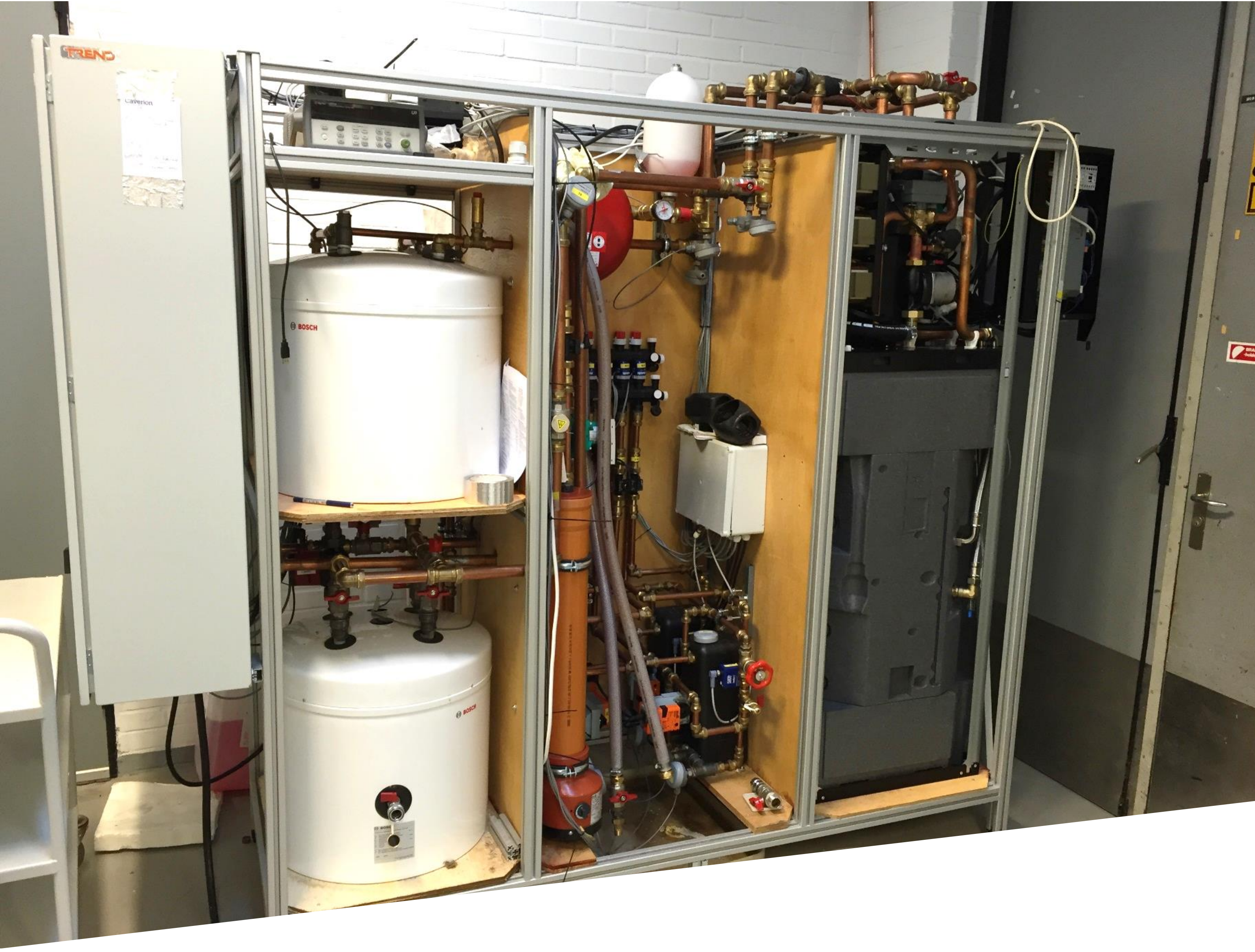

The OPSYS test rig

Energy and Climate

Appendix A

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Title: The OPSYS test rig

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November 2017
1st printing, 1st edition, 2017

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Front page: the OPSYS test rig

Preface

The present document is part of the documentation of the *Underfloor heating and heat pump optimization* project funded by the Danish Energy Agency through the EUDP programme, project no. 64014-0548.

The document describes the developed OPSYS test rig for testing of control strategies for optimization of the combined heat pump and heat emitting system.

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1 Introduction

The purpose of the project was to minimize the gap between the accredited efficiency of domestic heat pumps and the actual efficiency when installed in a house. Unfortunately, measurements on existing heat pump installations have shown Seasonal Performance Factors (SPF: mean annual efficiency) well below expectations as the heat pumps and the heat emitting systems are rarely properly adjusted at the installation of the heat pumps, and the operating parameters are not continuously adjusted according to the actual operating conditions (Jensen et al, 2017). As an example, the supply temperature is often set too high in order to guarantee a sufficient space heating. A supply temperature higher than needed results in a lower SPF.

Typically, an increase of 1°C in the temperature difference between the cold and the hot side of a heat pump leads to a decrease of 2-3% in the COP (instant efficiency of the heat pump). For most heat pumps, the only control and means of reducing the supply temperature is a simple ambient temperature correction, which, however, rarely leads to an optimal supply temperature. A too high supply temperature also has consequences for the heat emitting system. The volume flow through the system fluctuates due to uncoordinated openings and closings of valves in the system, e.g. manifold valves for an underfloor heating system. The higher the supply temperature is above the minimum required supply temperature, the more the amplitude of the fluctuations increases (Jensen, Olesen and Paulsen, 2014). The fluctuating flow causes the heat pump to fluctuate in produced heat power resulting in a reduced COP compared to the optimal COP at the actual temperature level. The larger fluctuations, the higher the decrease in efficiency.

The aim of the project was to minimize the above problems, so that the end users receive the expected efficiency from their heat pump installations. Thus, the aim was to develop integrated controllers for the heat pumps and the heat emitting systems in order to reduce the supply temperature and the volume flow fluctuations.

Preliminary results from a study financed by the Strategic Research Centre on Zero Emission Buildings (Jensen, Olesen and Paulsen, 2014) indicate a theoretical potential for improving the COP of an installed heat pump by approx. 15 % by optimizing the volume flow. The study shows an equally large improvement when keeping the forward temperature as low as possible.

A main part of the project has been the development of a test facility where new and more advanced control possibilities can be tested in a controlled, yet realistic, environment. The developed test rig is described in detail in the following chapters.

2 Test rig

A dynamic experimental setup has been constructed. The system (test rig) emulates a house with an underfloor heating system to which a ground source heat pump can be connected. Figure 2.1 shows a principle sketch of the system. The system has two main elements denominated the hot side and the cold side, regarded from the heat pump (cold side = evaporator side, hot side = condenser side).

The hot side emulates the underfloor heating system (can also emulate a radiator system) with the possibility of using a buffer tank. The underfloor heating system is emulated via a series of parallel-connected heat exchangers resembling each room in the house. Hot water draw off may also be emulated, but is at currently not part of the test setup.

The heat consumption is programmable in order to simulate different sized rooms of a house with different load conditions. The controller of the experimental setup is running a simulation program which calculates the heat consumption and provides an emulated room temperature as well as an emulated return temperature of the water from each "room" as input to the control of the manifold (Appendix D). In this way, it is on one hand possible to control an underfloor heating system like in an ordinary home while on the other hand different, more advanced, control strategies may also be tested. The size and function of the "rooms" can easily be altered by changing the load pattern and heat loss of the "rooms" in the simulation program.

The cold side of the experimental setup (see figure 2.1) emulates a heat source, e.g. the ground. This is an electric heater, which is controlled in order to emulate a brine temperature. With this method, seasonal variations of the ground temperature and different lengths of tubes in the ground can be emulated as well.

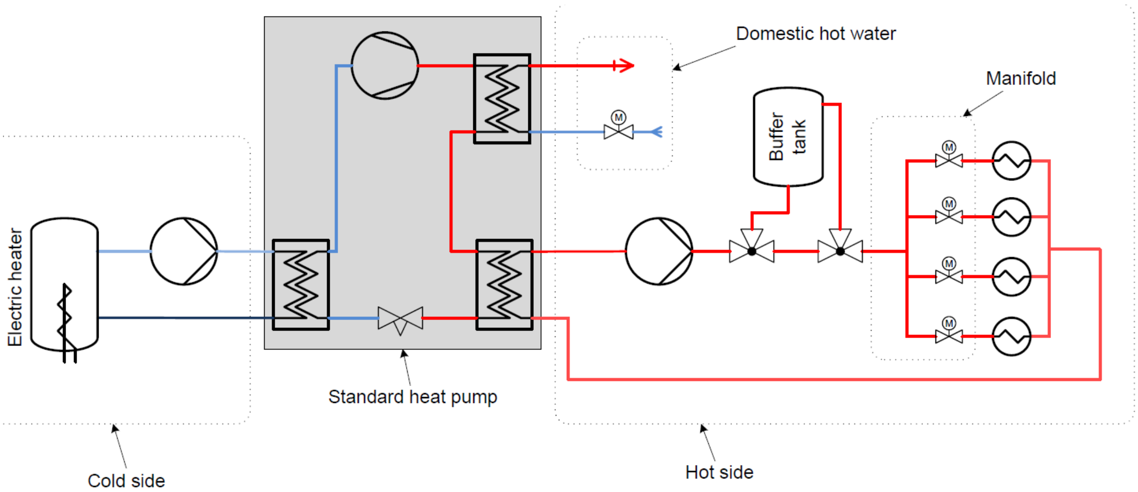


Figure 2.1. Principle sketch of experimental setup.

2.1 Layout of test rig and control

Figure 2.2 shows a picture of the developed test rig, and figure 2.3 shows the main components of the test rig in the form of a PI-diagram (Piping and Instrumentation diagram). Figure 2.4 shows the connection between the physical test rig and the virtual house/control system.

The heat emitting system of the house is emulated by four heat exchangers – Zone 1-4 in figure 2.4, although the heating system in a Danish house consists of 10-11 underfloor heating circuits/radiators. Four heat exchangers were chosen in order to reduce the size and complexity of the test rig. However, more heat exchangers may be added later.

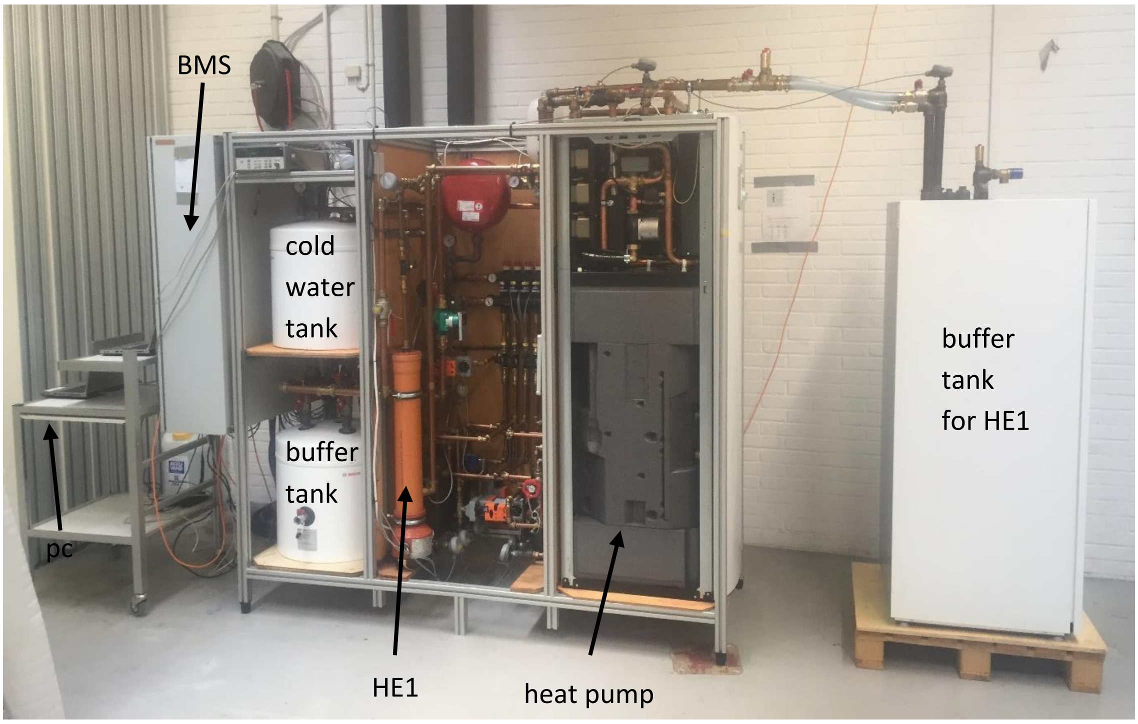


Figure 2.2. Photo of the test rig.

Figure 2.4 shows that the test set up consists of a physical part (shown in figure 2.2) and a virtual part. The components of the physical part are shown in figure 2.3. The virtual part consists of a python program running on a pc connected to the physical test rig – see also Appendix B.

A simulation program in the language Dymola (Dassault Systèmes, 2015) is running a model of a typical Danish house (Appendix C). The simulation program (Appendix D) calculates the actual heat demand of the four rooms (the four heat exchangers of the test rig) on a continuous basis. Based on this, the simulation program determines the forward temperature from the heat pump and the return temperature from the heating system of each room. A PID controller is adjusted to give the calculated return temperature from the four heat exchangers (see Zone Nz in the top right corner of figure 2.4). In order to create a heat demand of the four heat exchangers, these are connected to the common cooling system of the laboratories of Energy and Climate at Danish Technological Institute. The forward temperature of the common cooling system is, however, varying, so a buffer tank (cold water tank in figure 2.2) is placed in-between the common cooling system and the four heat exchangers in order to create a stable temperature of the cooling. This buffer tank is keep at a constant temperature.

The forward temperature of the heat pump is controlled via the outdoor sensor of the heat pump. The temperature sensor is replaced by a variable volt signal to the controller of the heat pump. By varying the voltage level, the heat pump assumes that the ambient temperature is the one calculated by the simulation program. The calculated ambient temperature is given in such a way that the heat pump, via the programmed heating curved in the internal control of the heat pump, is manipulated to give the desired forward temperature to the heating system.

The electrical heating element, HE1, in the left bottom corner of figure 2.3 is controlled in order to give the heat pump the desired brine temperature. HE1 is controlled in order to give a brine temperature that matches the time of year run by the simulation program. The variation of the brine temperature is explained in Appendix C.

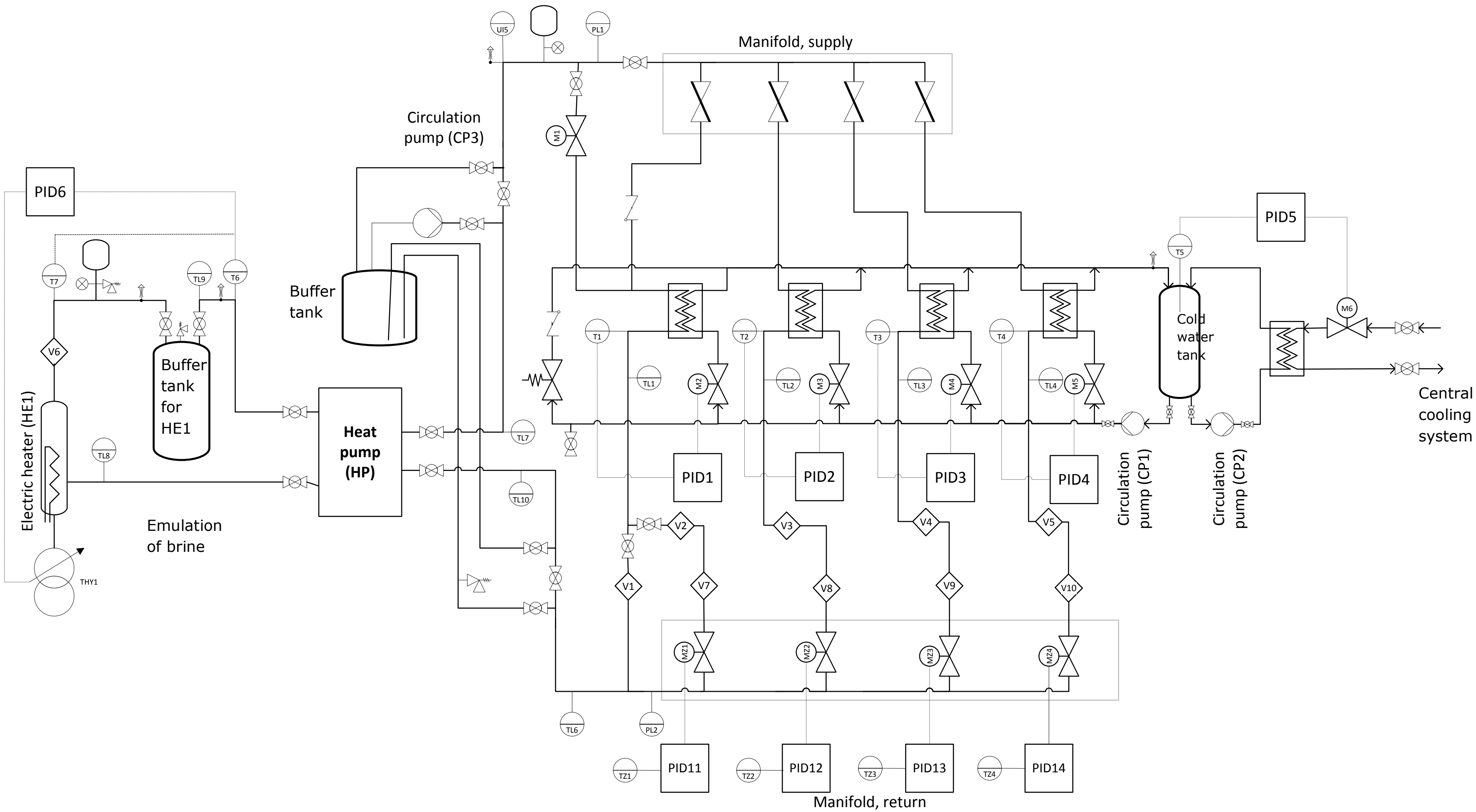


Figure 2.3. PI-diagram showing the main components of the test rig. The figure shows several PID controllers. The parameters of the PID controllers are given in Appendix 1. As the parameter for the D part of the PIDs are zero, the PID controllers are actually PI controllers.

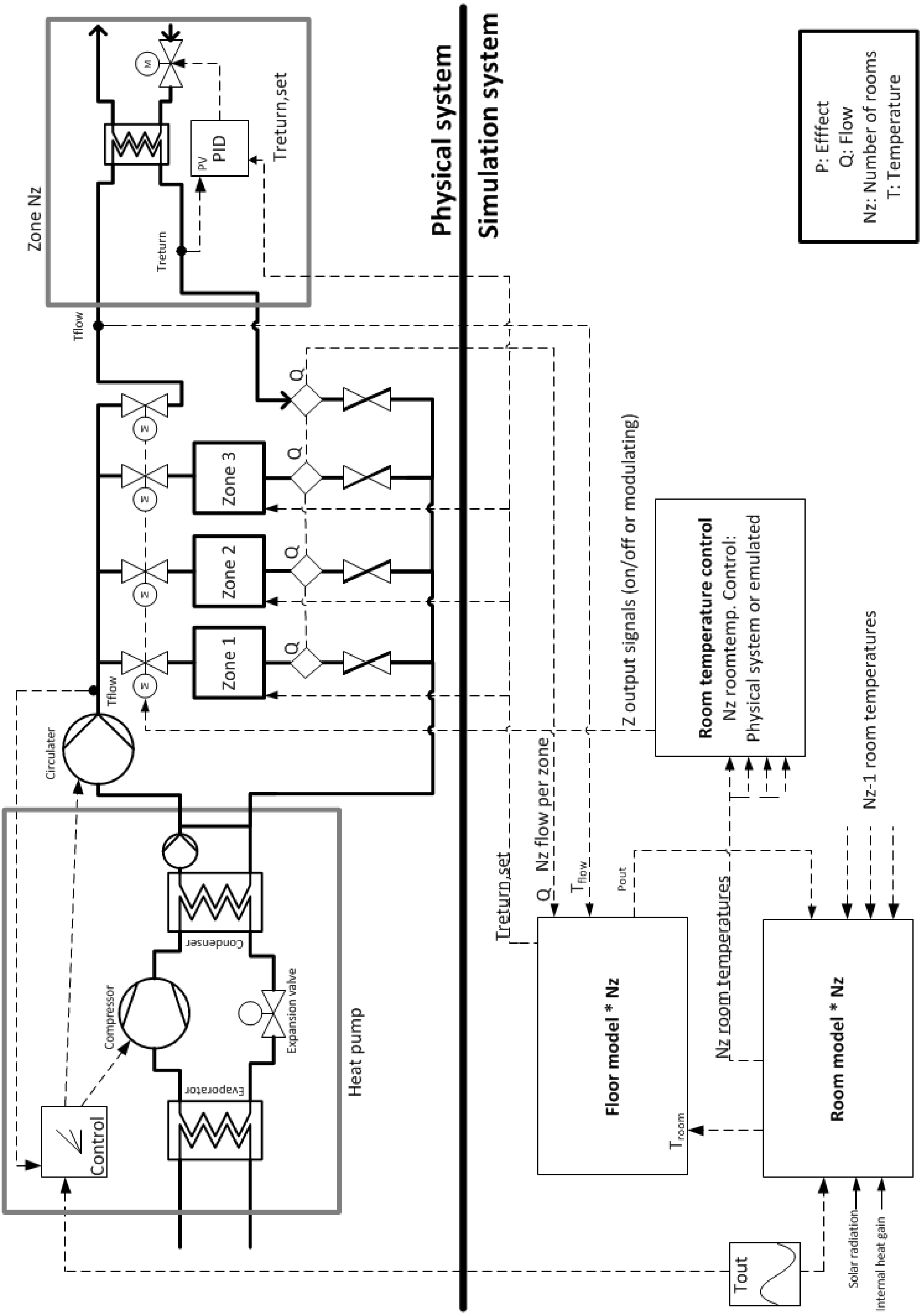


Figure 2.4. The connection between the physical test rig and the virtual house/control system.

2.2 Components of the physical test rig

The main blocs of the physical test rig are the emulation of the heat emitting system (red circle in figure 2.5, the heat pump (blue circle in figure 2.5), and the measuring system (sensors are shown in figure 2.3) as well as the control system (BMS – Building Management System) shown in figure 2.6.

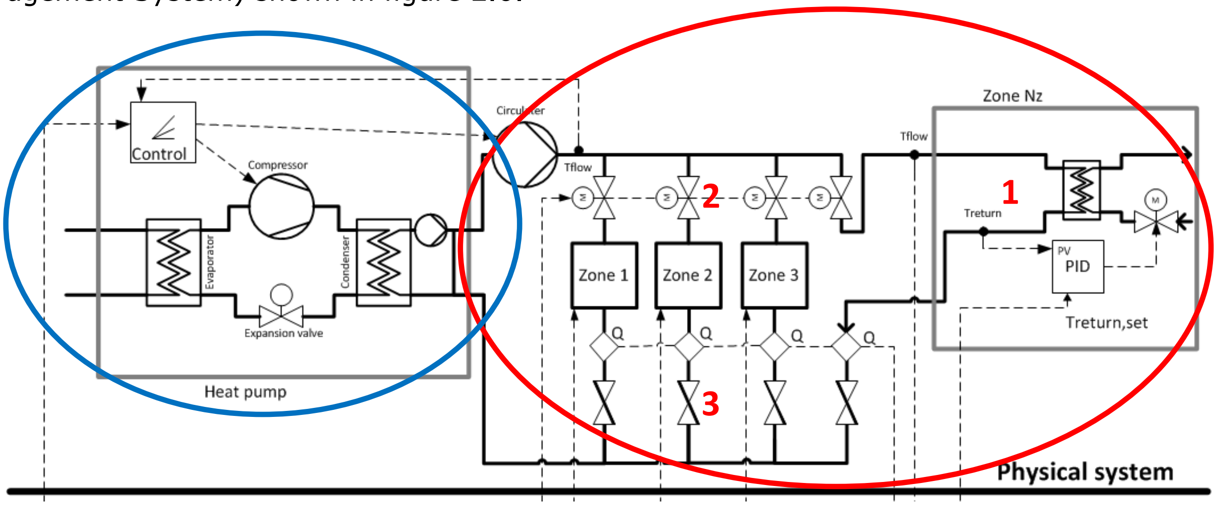


Figure 2.5. The physical part of the test rig shown in figure 2.4.

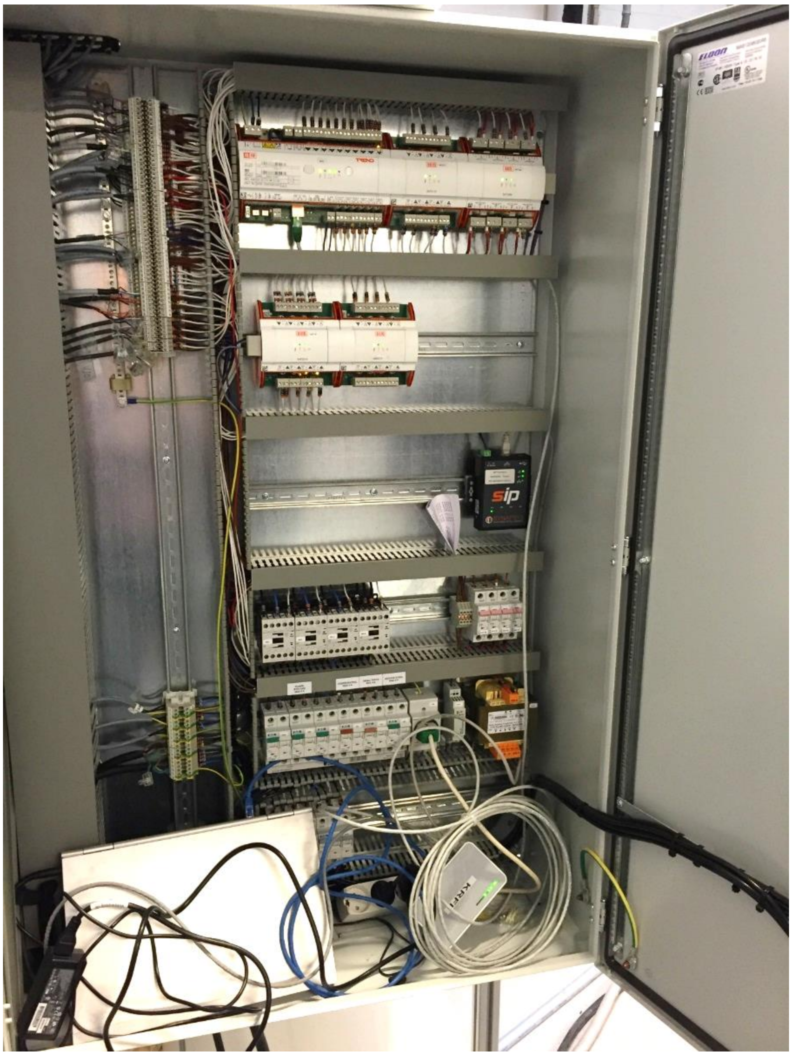


Figure 2.6. The Building Management System of the test rig.

2.2.1 The heat emitting system

The heat emitting system consists of four subsystems. Each subsystem consists of:

- a PID controlled heat exchanger cooled by the cooling system at the department of Energy and Climate, Danish Technological Institute – 1 in figure 2.5
- an actuator controlled by a wax motor – 2 in figure 2.5
- a balancing valve – 3 in figure 2.5

Figure 2.7 shows pictures of the heat emitting system of the test rig. From the start, the test rig was equipped with four heat exchangers in order to reduce the complexity. It is, however, possible to expand the test rig with more heat exchangers if this becomes necessary in connection with the testing.

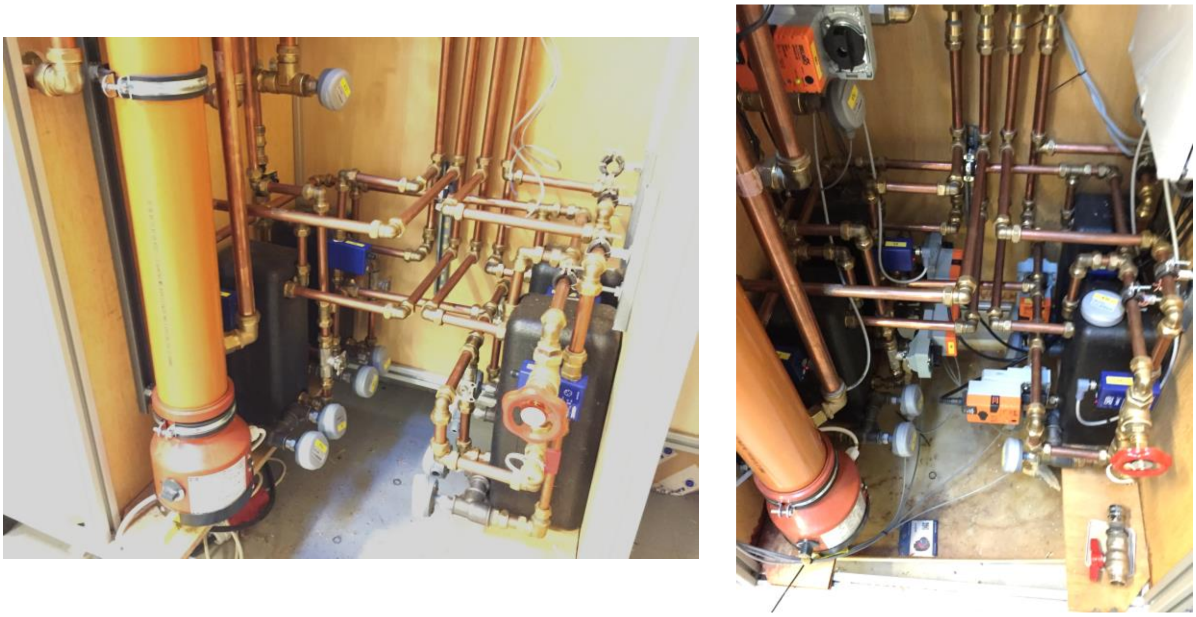


Figure 2.7. The heat emitting system of the test rig.

2.2.1.1 Heat exchangers

The heat exchangers acting as heat emitters are PHE-TYPE: LP80Tx40 from Reci. Each heat exchanger has a capacity of 8 kW. The heat exchangers are connected to the central cooling system at the department of Energy and Climate, Danish Technological Institute in order to be able to emulated the simulated heat demand of the rooms. The forward temperature of the central cooling system is, however, fluctuating as the cooling is used for different purposes. Therefore, a heat exchanger and a 50 litre tank are placed in between the central cooling system and the heat exchangers emulating the heat demand of the rooms. The heat exchangers and the tank between the central cooling system and the heat exchangers of the heating part of the test rig are shown to the right in figure 2.3, and the tank is the "cold water tank" in figure 2.2. A PID controller (PID5 in figure 2.3) ensures a constant temperature in the insulated 50 litre cold water tank from Bosch. The tank temperature depends on the simulated building in question, but it will typically be between 15 and 20°C.

Figure 2.8 shows that it is possible to obtain a return temperature from the heat exchangers which is very similar to the simulated return temperature of the underfloor heating in the model of the house, when there is flow in the system. This temperature is naturally very different from the simulated temperature, when there is no flow in the heat exchangers, due to different thermal capacities of the test rig compared to the thermal capacity of the floor in the simulation. This is, however, of no importance for the tests as the measured return temperature is quickly equal to the simulated return temperature when the flow returns.

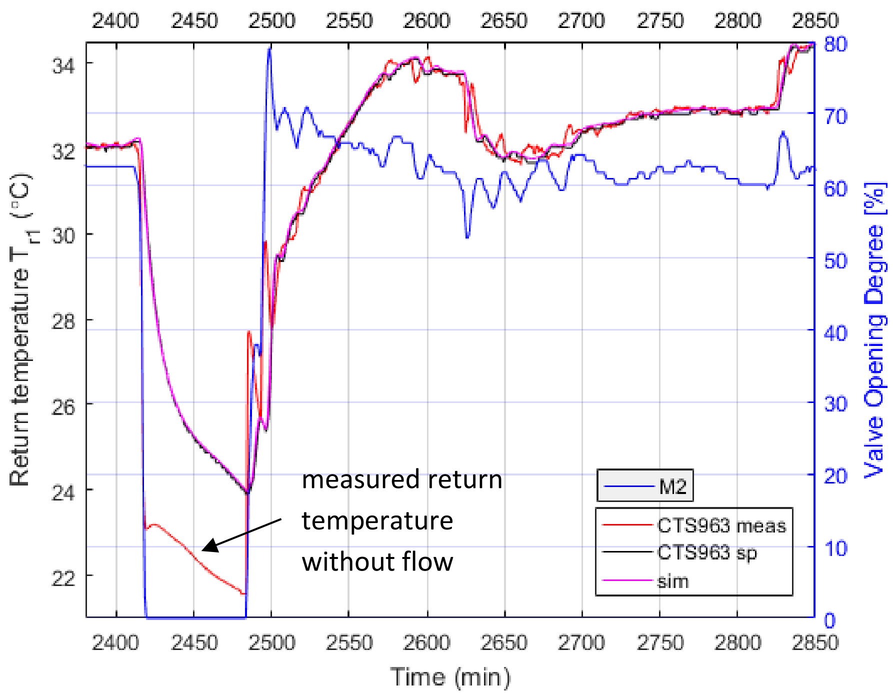


Figure 2.8. Measured and simulated return temperature from one heat exchanger.
sim: the simulated return temperature
CTS963 sp: the return temperature, which the BMS asks the test rig to maintain
CTS962 measured: the actual obtained and measured return temperature.

2.2.1.2 Actuators

The four actuators (MZ1-4 in figure 2.3) on the return side of the heat exchangers emulating the heating system are from the firm Uponor. Each actuator consists of a valve with a wax motor for opening and closing of the valve. There is a resistance-heating element in the wax motors. When heated, the wax expands and opens the valve, and when switching off the heat, the wax will shrink and close the valve. It takes 300 seconds from fully closed to fully open and vice versa. Figure 2.9 shows a picture of the actuators.

The actuators are controlled by the BMS system of the test rig. The actuators can either be on/off controlled or kept partly open. The latter is achieved by pulsing the power to the heating element in the wax motors, which will keep the valves partly open due to partly melted wax. However, a completely stable opening degree is not possible to obtain.

2.2.1.1 Balancing valves

Balancing valves are located on the supply side of the heat exchangers – see figure 2.3. The four heat exchangers resembles different parts of the underfloor heating system with different heat demands and different pressure losses. The purpose of the balancing valves is to adjust the pressure loss over the heat exchanger circuits in order to obtain the simulated flows from the simulation of the house. The balancing valves, also shown in figure 2.9, are from Uponor.

2.2.1.2 Buffer tank

Figures 2.1 and 2.2 show a 50 litre insulated buffer tank from Bosch in the heat emitting circuit. The buffer tank may be utilized for several purposes. It can add volume to the heat emitting system as the four heat exchangers contain less water than the pipes in the underfloor heating system or the radiators in a real house. The buffer tank may also be utilized for studying flexibility as the heat pump may heat the buffer tank when excess electricity is available in the grid, so that the heat pump can be switched off during a following period with lack of electricity in the grid.

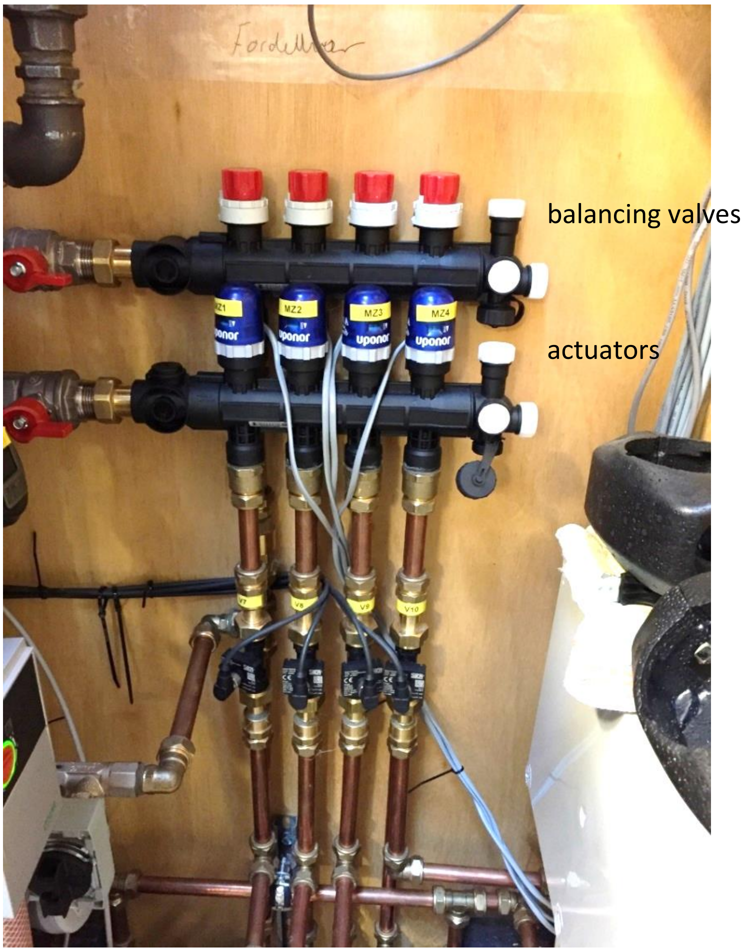


Figure 2.9. The actuators for controlling the flow through the four heat exchangers and the balancing valves.

2.2.2 The heat pump

The heat pump of the test rig can be change so that it is possible to investigate heat pumps from different manufactures and different types of heat pumps.

The first heat pump installed in the test rig, se figure 2.2, is a ground source heat pump from Bosch: Bosch Compress 7000 LWM 3-12 kW (Bosch, 2017). The heat production can be varied continuously between 3 and 12 kW. Below 3 kW, on/off control is necessary.

One of the aims of the project was to investigate how an optimal forward temperature from the heat pump will improve the overall efficiency of the heating system, including the heat pump. The forward temperature calculated by the simulation program is obtained by manipulating the ambient temperature sensed by the heat pump.

In normal installations, the forward temperature is based on the measured ambient temperature and the heating curve programmed in the control of the heat pump. This has been utilized in the test rig. The ambient sensor of the heat pump is replaced with at controllable voltage signal, which - when knowing the heating curve of the heat pump - may be adjusted to trick the heat pump to deliver the desired forward temperature.

A resistant heating element, HE1 in figures 2.2 and 2.3, emulates the brine side of the heat pump. To obtain a stable temperature of the brine, the heating element, HE1, is connected to a 300 litre insulated buffer tank from Bosch – "buffer tank for HE1" in figure 2.2. The heating element, HE1, is controllable between 0 and 7 kW and is, therefore, approx.. 1.5 kW too small for the max power of the installed heat pump from Bosch. HE1 is controlled by PID6 via THY1. The latter is a thyristor from OJ Electronics, type EFS-9253. The input to PID6 is a combination of T6 and T7 in figure 2.3. This combination was in the baseline test (Appendix F): 0.8*T6+0.2*T7.

2.2.3 The measuring system

The measurements of the system are obtained via three different systems:

- the BMS system
- virtual values from the simulation program
- a data logger that does not transfer measurements to the BMS system

The measurements are all saved in a database on the pc running the test rig. Appendix B describes how to retrieve data from the database.

2.2.3.1 Measurements from the BMS system

The BSM system is described in section 2.2.4. Figures 2.10-2.12 show screen dumps from the pc running the test rig. The screen dumps are from the BMS system. The BMS system may both be controlled automatically via the simulation and control program on the pc of the test rig or be manually controlled. See also figure 2.3 for the location of the components in the PI-diagram.

Figure 2.10 shows the control screen for the four heating zones of the test rig. The zones are denominated zone 1-4: top left is zone 1, top right is zone 2, bottom left is zone 3 and bottom right is zone 4. The four zones are identical except for the bypasses on each side of the heat exchanger in zone 1. The purpose of these bypasses is to allow fast step response tests where the total flow of the system is only going through the heat exchanger of zone 1. An additional valve named M1 and a flow meter called V1 allows for this to occur.

The wording in figure 2.10 is in Danish. Below the wording of zone 4 is translated into English.

At the top of the screen, the colours of the values are explained:

- Farvekode => Colouring code
- Grøn=Fysisk værdi => Green = Measured values
- Orange=Kalkuleret værdi => Orange = Calculated value (calculated by the BMS)
- Blå=CTS indstilling => Blue = BMS set point
- Sort=Simulated værdi => Black = Simulated value

The common sensors, meters, and set points of the four heating zones are:

- TZ1-4: room temperature simulated by the house model of the test rig.
- T1-4: simulated and measured return temperature from the heat exchangers. The sensors are TENA NTC 10 sensors from Produal
- V2-5: measured volume flow in the heating circuit for measuring flows between 0.25 and 5 l/min. The flow meters are SIKA magnetic induction flow meters model VMZ081S1PEG24320
- V7-V10: measured volume flow in the heating circuit for measuring flows between 2 and 40 l/min. The flow meters are SIKA vortex flow meters, model VVXA1SGAU1U11514

- the red value under e.g. V2 and V7 in zone 1 (same for zone 2-4) is the resulting flow rate from the two meters V2 and V7. Below 2 l/min, the values from V2 is used while the values from V2 is used above 5 l/min. In between, a mix of the two meter signals is calculated.
- MZ1-4: the opening degree of the Uponor actuators – calculated by the BMS. The actuators are controlled by PID11-14 based on the simulated room temperatures
- M2-5: opening degree of the valves on the cooling side of the four heat exchanges determined by PID1-4. The motor valves are from Belimo, model LRQ24A-SR

Extra measurements in zone 1:

- V1: measured volume flow in the bypass of zone 1. The flow meter is a SIKA vortex flow meter, model VVXA1SGAU1U11514
- M1: the opening degree of the valve in the bypass of zone 1 can be determined by the control program. The motor valves are from Belimo, model LRQ24A-SR

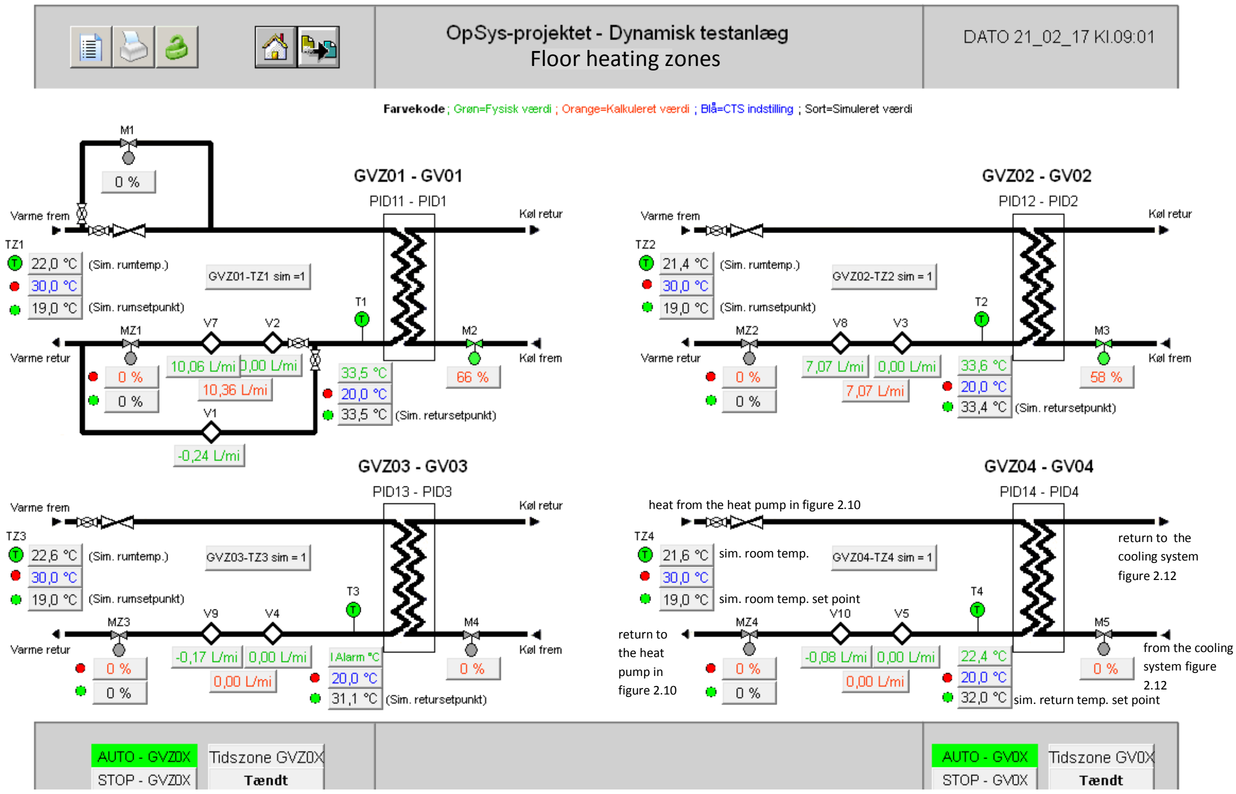


Figure 2.10. The BMS screen for controlling the four heating zones of the test rig.

Figure 2.11 shows the control screen for the heat pump and the brine side of the test rig.

The sensors, meters and set points of the control of the heat pump and brine are:

- UT sim: ambient temperature calculated by the control to obtain the desired forward temperature from the heat pump
- T6: temperature of the brine to the heat pump. The temperature of the brine is dependent on the time of the year as defined in Appendix C. The temperature is measured by a TENA NTC 10 sensor from Produal
- V6: measured volume flow rate of the brine. The flow meter is a SIKA vortex flow meter, model VVXA1SGAU1U11514

- T7: temperature of the water to the buffer tank between HE1 (HE01 in figure 2.11) and the heat pump. The temperature is measured by a TENA NTC 10 sensor from Produal
- THY1: control of the heating element HE1. THY1 is controlled by PID6
- CP3: manually controlled pump to activate the buffer tank in the heating system. The pump is from Grundfos: Alpha2 25-40
- UI5: measured forward temperature from the heat pump. The temperature is measured by a TENA NTC 10 sensor from Produal
- UI1-4: input to the heat pump for more advanced control of the heat pump than just manipulating the ambient temperature. Not presently utilized
- UA1-5: output from the heat pump for more advanced control of the heat pump. Not presently utilized

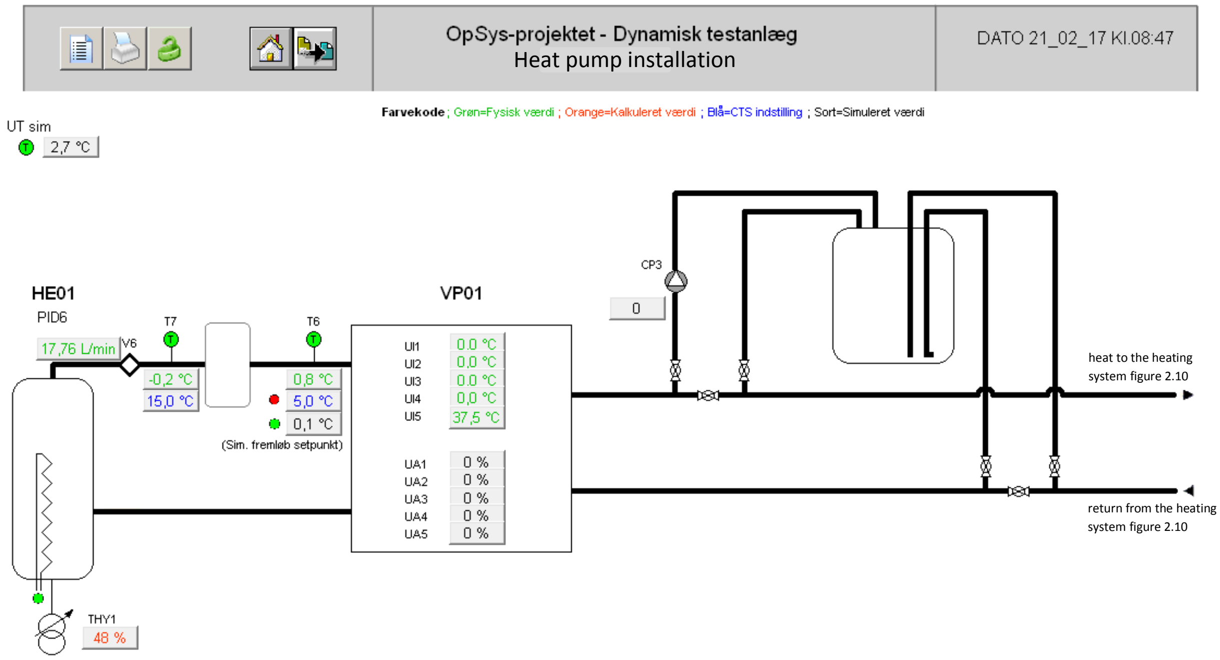


Figure 2.11. The BMS screen for controlling the heat pump and the brine side of the test rig.

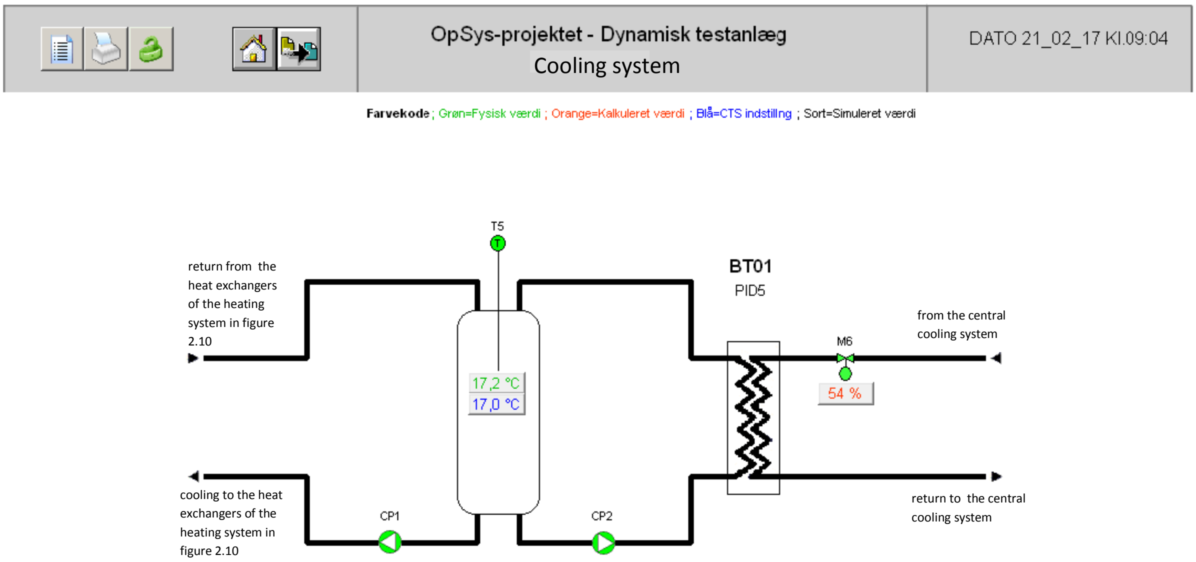


Figure 2.12. The BMS screen for controlling the cooling system of the test rig.

Figure 2.12 shows the control screen for the cooling system of the test rig.

The sensor and the valve in the cooling system of the test rig:

- T5: set point and measured temperature of the cold water tank. The temperature is measured by a TENA NTC 10 sensor from Produal
- M6: opening degree of the valve controlling the cooling to the cold water tank. The motor valves are from Belimo, model LR24A-SR. The valve is controlled by PID5
- CP1-2: circulation pumps from Grundfos: Alpha2 25-40. The two pumps run at constant speed

2.2.3.2 Values from simulation and control system

Figures 2.10-12 already show some values from the simulation system and the control system. The simulation system and the control system are running on the pc of the test rig. The simulation of the house produces many values of which only few are transferred to the BMS and logged in the database. The logged values are:

- the pseudo ambient temperature in order to trick the heat pump to deliver the desired forward temperature
- the forward temperature from the heat pump
- the temperature of the brine to the heat pump
- the return temperature from the four heat exchangers
- the volume flow rate in the four heat exchangers
- the position of the actuators on the four heat exchangers
- the set points of the four room air temperatures
- the room air temperatures

2.2.3.3 Values from data logger

The data logger is a 34970A LXI Data Acquisition / Switch Unit from Agilent. The purpose of several of the measured temperatures is to check the temperature measurements of the BMS. The meter and the sensors connected to the data logger are – see figure 2.3:

- TL1-TL4: measured temperature located beside T1-T4. The sensors are TENA PT 1000 sensors from Produal
- TL5: not in use
- TL6: measured temperature of the water from the heating system to the heat pump before the branch to the buffer tank. The temperature is measured by a TENA PT 1000 sensor from Produal
- TL7: measured forward temperature from the heat pump. The temperature is measured by a TENA PT 1000 sensor from Produal
- TL8: measured temperature of the brine to the heat pump. The temperature is measured by a TENA PT 1000 sensor from Produal
- TL9: measured temperature of the brine leaving the heat pump. The temperature is measured by a TENA PT 1000 sensor from Produal
- TL10: measured temperature of the water from the heating system to the heat pump after the branch to the buffer tank. The temperature is measured by a TENA PT 1000 sensor from Produal
- PL1: measured pressure at the outlet from the heat pump to the heating system. The pressure transducer is VPL 16-N from Produal
- PL2: measured pressure at the return from the heating system to the heat pump. The pressure transducer is VPL 16-N from Produal
- energy meter for measuring the energy demand of the heat pump: Kamstrup 382M electricity meter with an S0-output: 1000 pulses per kWh

2.2.4 The BMS system

The BMS system of the test rig is composed by modules from Trend: one IQ4E and four 8UIO modules (two top rows in figure 2.6) (Trend, 2017). The BMS is developed and interfaced by the Trend 963 software (Trend, 2015). 963 is a Windows based software package, which provides a management interface between the user and the Trend IQ building control system.

The firm Caverion has installed and programmed the Trend BMS system on the test rig. Appendix 2 contains guidance on how to run the system – in Danish only.

The Trend BMS modules communicate with the components of the test rig via a sip ModBus/vIQ module (Synapsys, 2012). The sip is an interface between the BMS and the components of the test rig using the serial ModBus protocol.

Figure 2.13 shows the connection between:

- the simulation pc running the house model (as a FMU), the control software (Python code), and the (CTS) 963 software
- the Trend controllers (BMS) via the sip
- the data (Agilent) logger

The measured data, some simulated data and actuator signals, are stored on the simulation pc. This is described in detail in Appendix B.

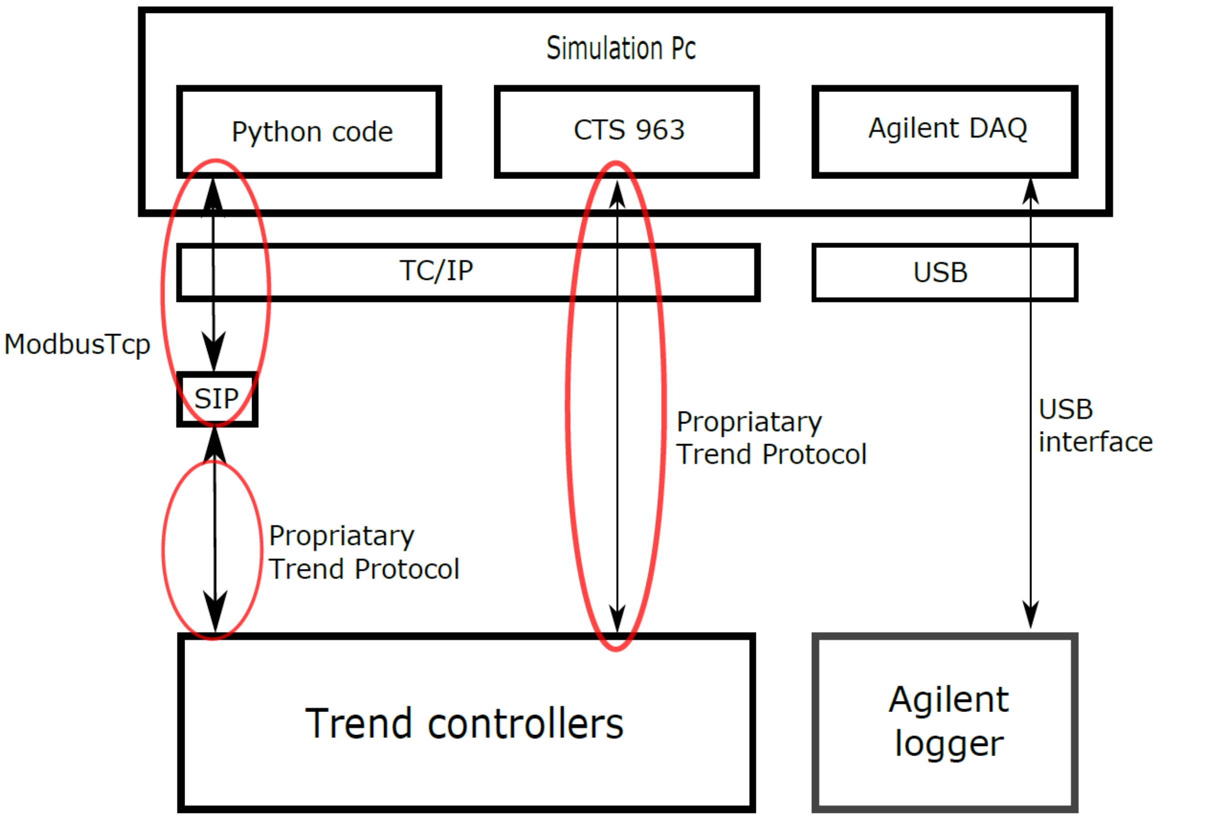


Figure 2.13. The connections between the test rig, the simulation pc and the data logger.

3 Main functions of the test rig

The OPSYS test rig is a hardware in the loop system where parts of the facility are hardware, while the other parts are virtually running on a computer – see figure 2.4.

- a heat pump is connected to hardware emulating the brine and heat emitting system
- the heat emitting system experiences an emulated heat demand created by a central cooling system

The virtual part of the test rig consists of:

- a simulation model of a typical Danish house from three ages (Appendix C)
- the house model is exposed to a virtual Danish weather and typical heat gains from people and appliances (Appendix C). The house model also contains the annual variation of the brine to a ground source heat pump (Appendix C)
- based on the results from the house model the control program controls the heat pump in order to give the desired forward temperature to the heat system of the house, and it controls the wax motors on the heat exchangers in order to obtain the desired flows through the emulated underfloor heating system

The control program gives the following control input to the BMS of the test rig – refer to figure 2.3:

- an artificial ambient temperature to the heat pump to obtain the simulated forward temperature of the heat pump via the programmed heating curve in the heat pump
- the actual brine temperature (T6), which PID6 obtains by controlling HE1 via THY1
- the desired temperature of the cooling (T5) to the heat exchangers in the emulated heating system. PID5 controls M6 in order to obtain the desired temperature
- based on the house model, the control program determines the return temperature from the heat exchangers (underfloor heating system/radiators). PID1-4 controls the return temperature of the water from the heat exchangers via the motor valves M2-5.
- the wax motors of the manifold (MZ1-4) are controlled by PID11-14. The control of MZ1-4 is based on the simulated room temperatures

4 References

Bosch, 2017. http://dk.documents.bosch-climate.com/download/pdf/file/6720813696.pdf

Jensen, S.Ø., Olesen, M.F. and Paulsen, O., 2014. Lightweight under floor heating systems and their influence on the efficiency of heat pumps (in both Danish and English). Danish Technological Institute. February 2014. ISBN 978-87-93250-01-7. On https://www.teknologisk.dk/strategisk-forskningscenter-for-energineutralt-byggeri/varmepumper-og-gulvvarmeanlaeg/38997,3

Jensen, et al. The good installation of heat pumps (in Danish). Danish Technological Institute and Insero. January 2017. https://ens.dk/sites/ens.dk/files/Varme/den_gode_varmepumpeinstallation.pdf

Dassault Systèmes, 2015. Dymola – Dynamic Modeling Laboretory, Dymola Release Notes. https://www.cenit.com/fileadmin/dam/3DS-PLM/PDFs/Dymola_Release_Notes_2015.pdf

Synapsys, 2012. sip ModBus/vIQ – Technical Guide Issue 5. Synapsys Solutions Ltd.

Trend, 2015. 963 Engineering Manual – applies to v3.71 software. Trend Technical Publications.

Trend, 2017. https://partners.trendcontrols.com/trendproducts/cd/en/ecatdata/pdf_iq4ebaclan_iq4_io_8uio.html

Appendix 1

The parameters of the PID controllers of the BMS system

The parameters of the PID controllers of the BMS system

The control of the test rig contains 10 PID controllers. The initial parameters of these controllers are listed below. In the initial configuration, the value of the D part of the controllers was zero, meaning that the controllers actually were PI controllers.

PID 1: P = -3.5
I = 1.8
D = 0

PID 2: P = -3.5
I = 1.8
D = 0

PID 3: P = -3.5
I = 1.8
D = 0

PID 4: P = -3.5
I = 1.8
D = 0

PID 5: P = -15.0
I = 2.0
D = 0

PID 6: P = 50
I = 10
D = 0

PID 11: P = 2.04
I = 2.88
D = 0

PID 12: P = 2.04
I = 2.88
D = 0

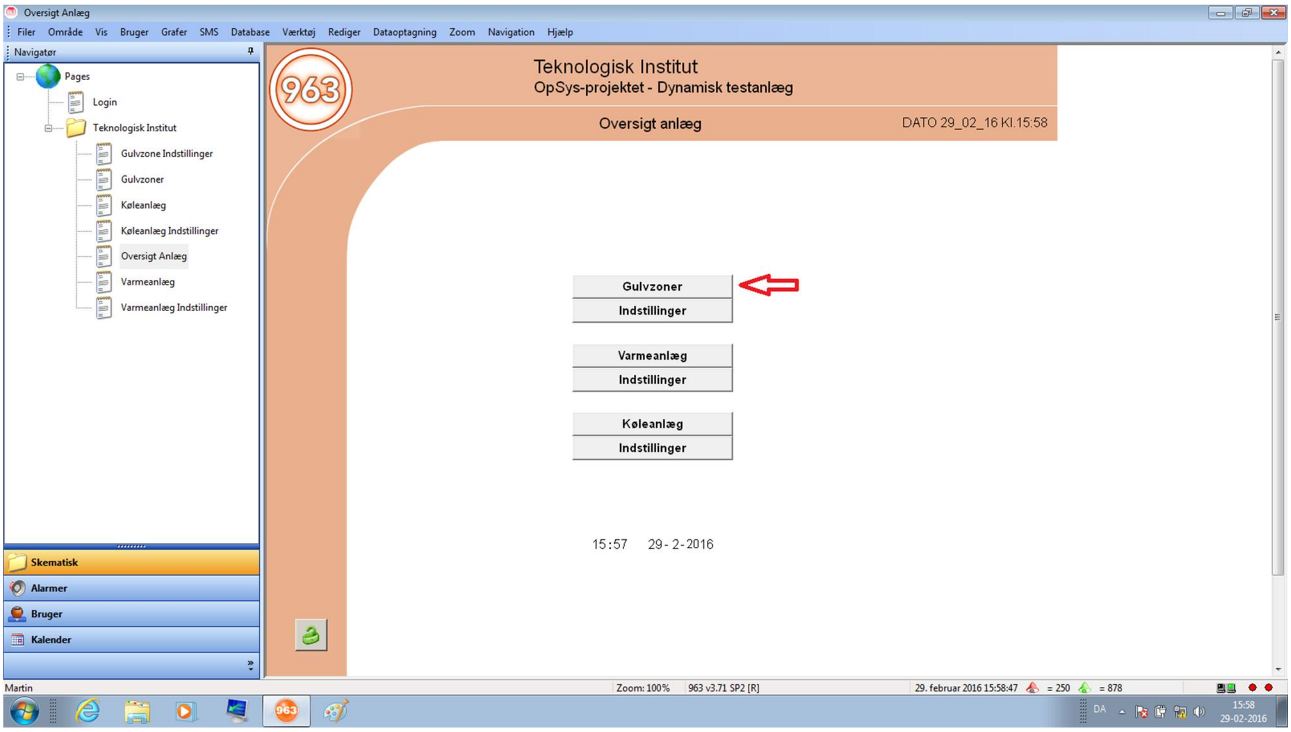
PID 13: P = 2.04
I = 2.88
D = 0

PID 14: P = 2.04
I = 2.88
D = 0

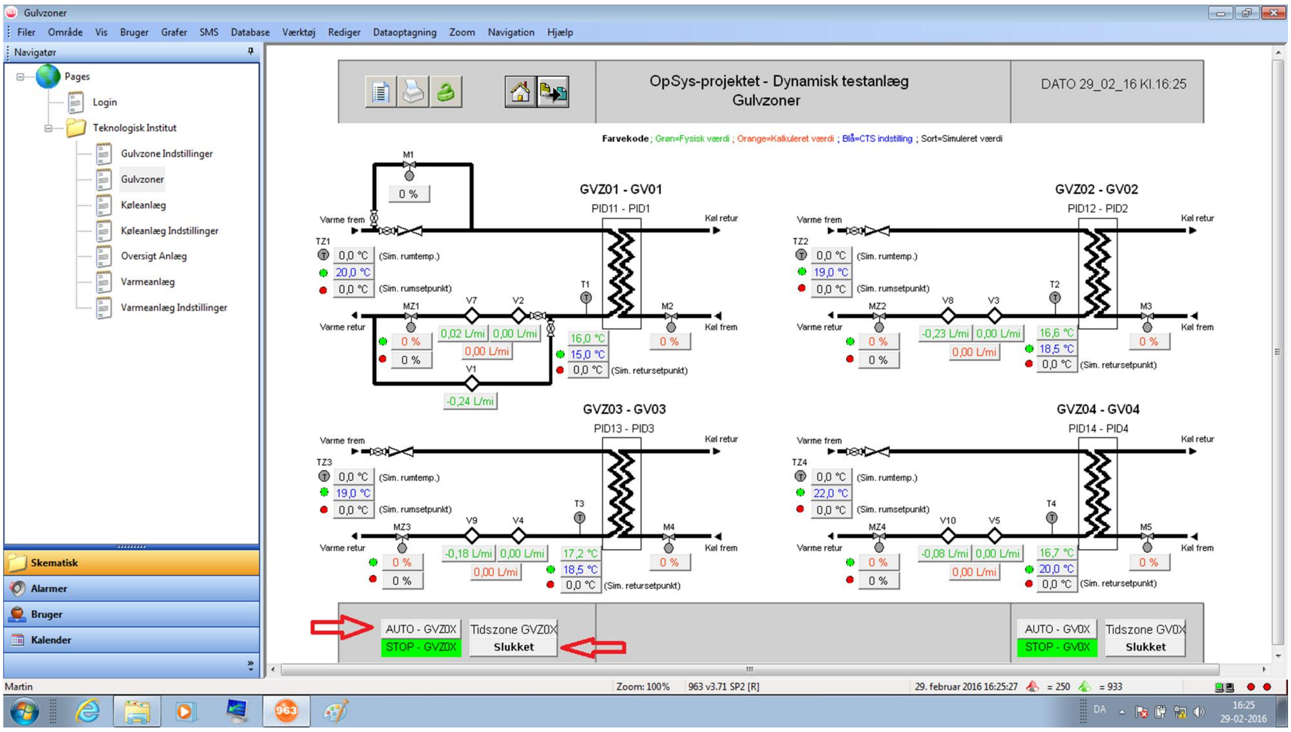
Appendix 2

Guidance on how to run the BMS of the test rig

Log ind som "Operatør" og siden "Oversigt anlæg" vises først.

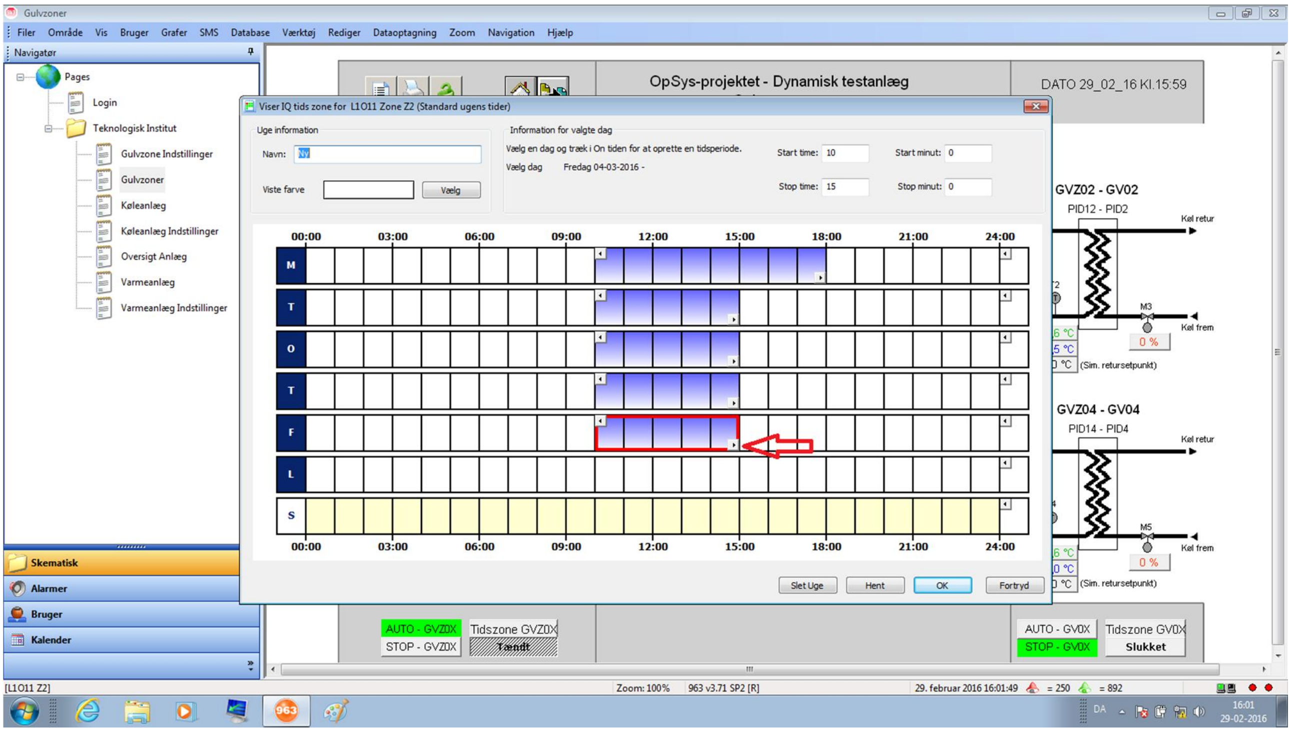


Klik på knappen "Gulvzoner" for at få vist nedenstående anlægsbillede.



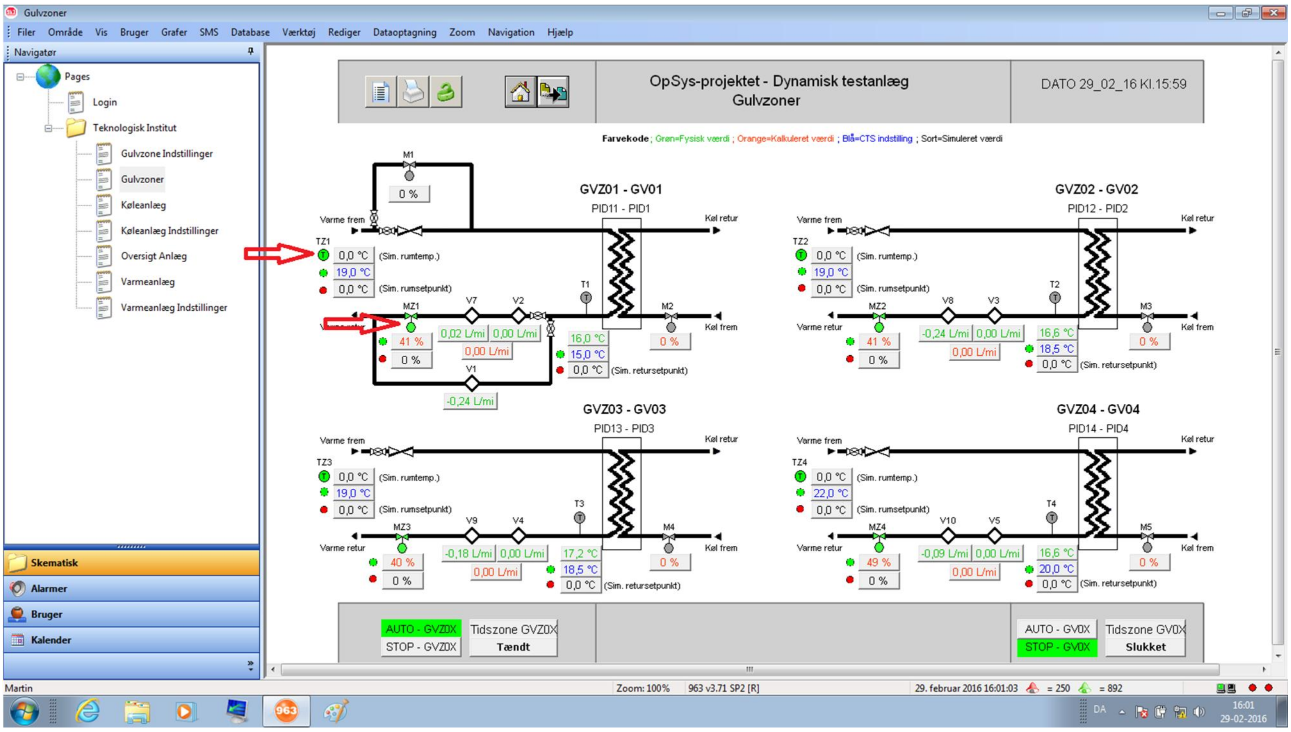
For at starte gulvvarme-reguleringer GVZ01-GVZ04 klik på knappen "AUTO – GVZ0X"

Der skal også vælges et tidsrum for drift af GVZ01-GVZ04. Klik på Knappen "Slukket" og følgende billede vises.



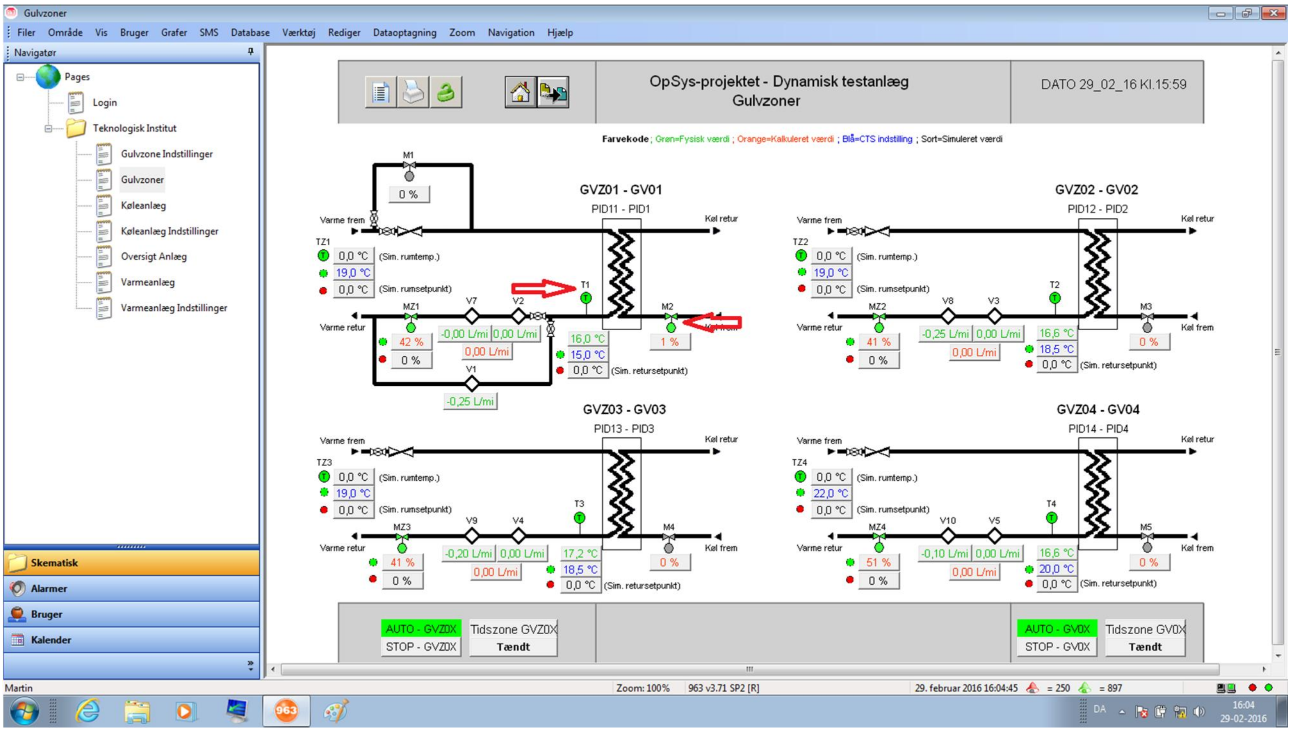
Drift tiden indstilles ved at trække i pilene i hver ende af den blå barre, for hver enkelt dag.

NB: der kan indstilles flere drift-tider pr. dag.



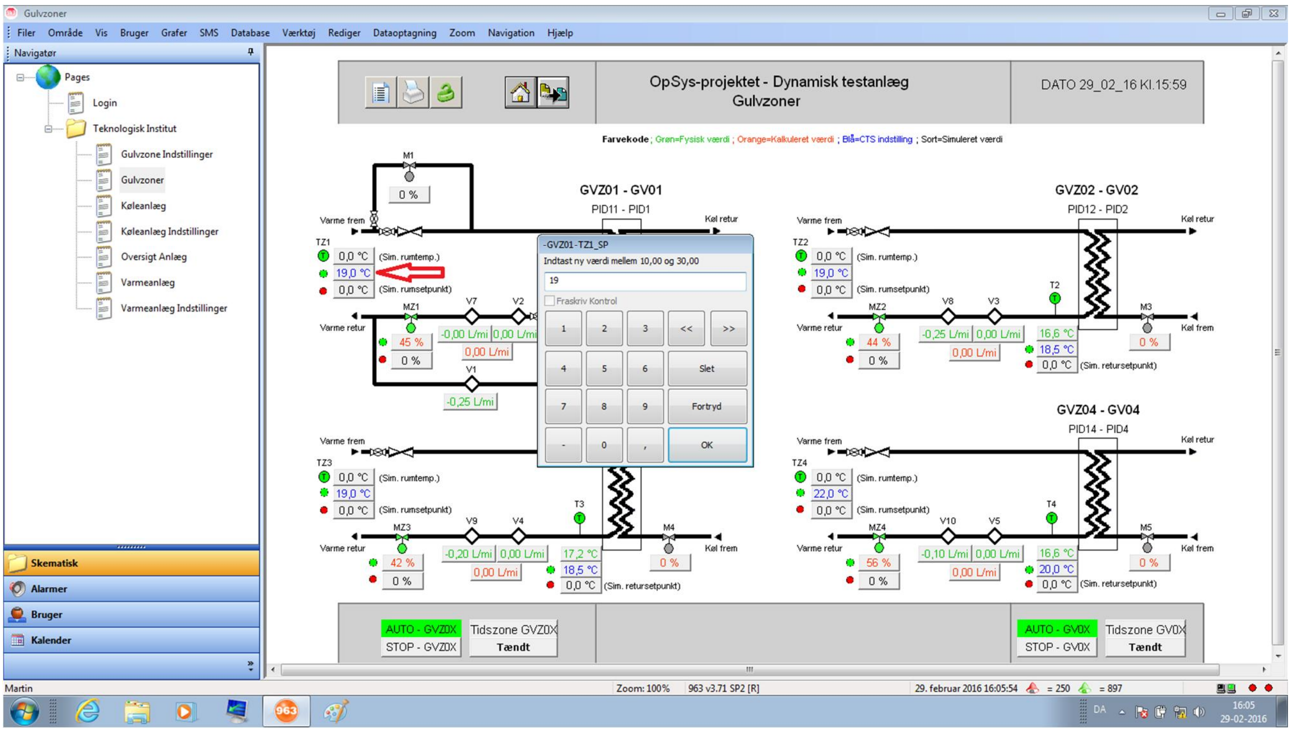
Drift af gulvvarme-reguleringer indikeres ved at TZ1-TZ4 skifter til grøn og ved varmebehov skifter MZ1-MZ4 til grøn + ventil-åbningsgrad angives nedenunder.

For at starte gulvkøle-reguleringer GV01-GV04 følges samme procedure og derefter ser anlægsbilledet således ud.

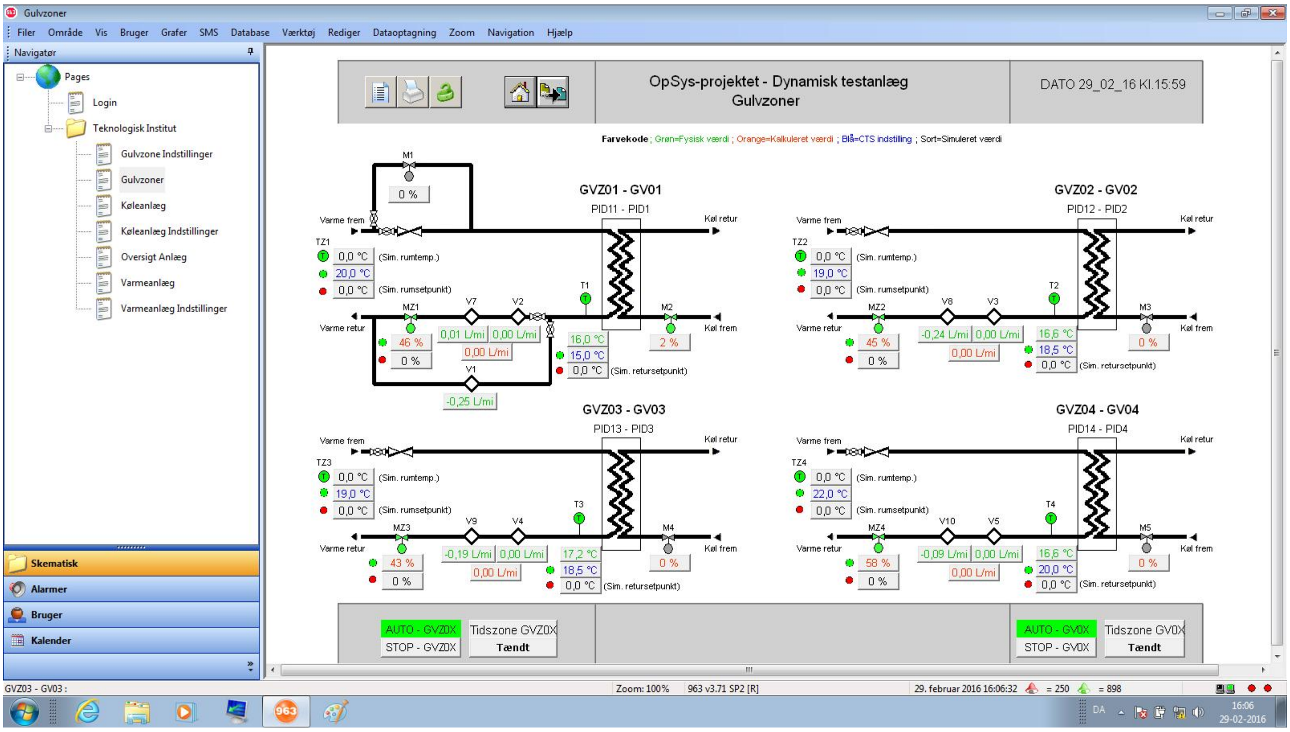


Drift af gulvkøle-reguleringer indikeres ved at T1-T4 skifter til grøn og ved kølebehov skifter M2-M5 til grøn + ventil-åbningsgrad angives nedenunder.

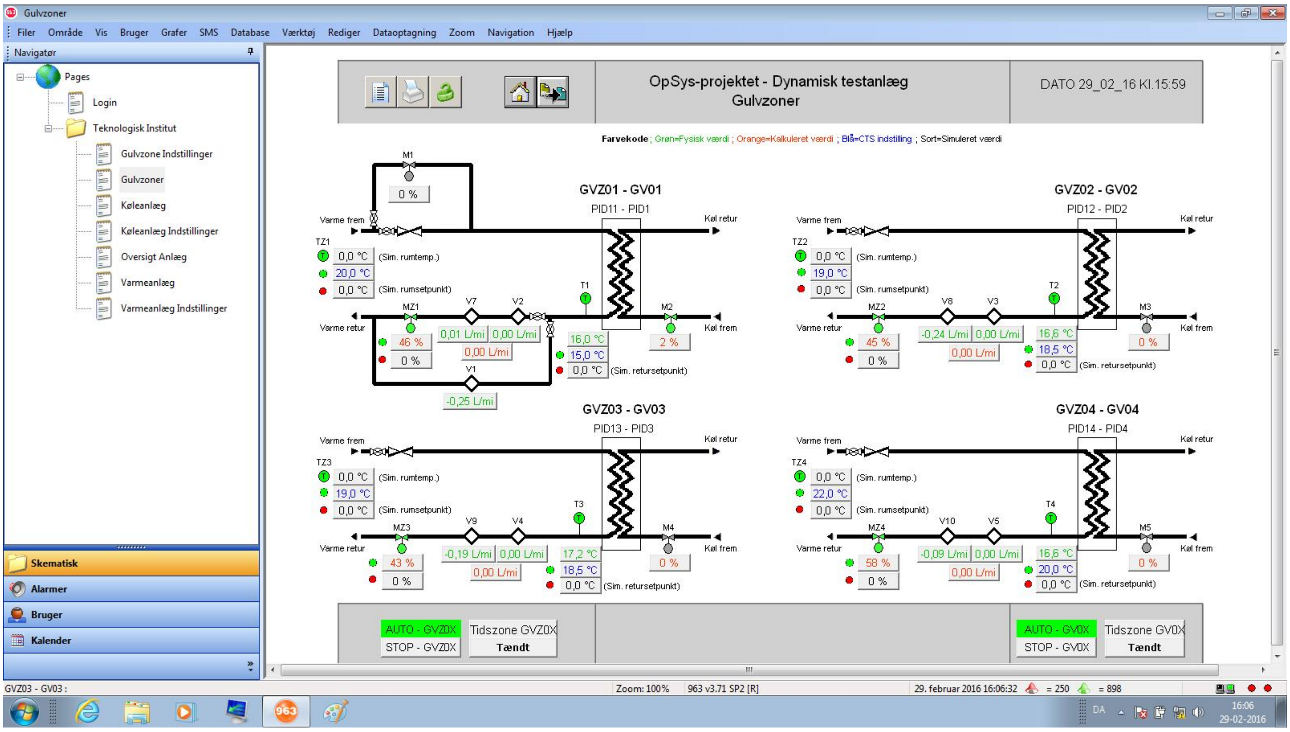
For at ændre rumtemperatur-setpunkt klik på knappen med blå skrift ved TZ1-TZ4.

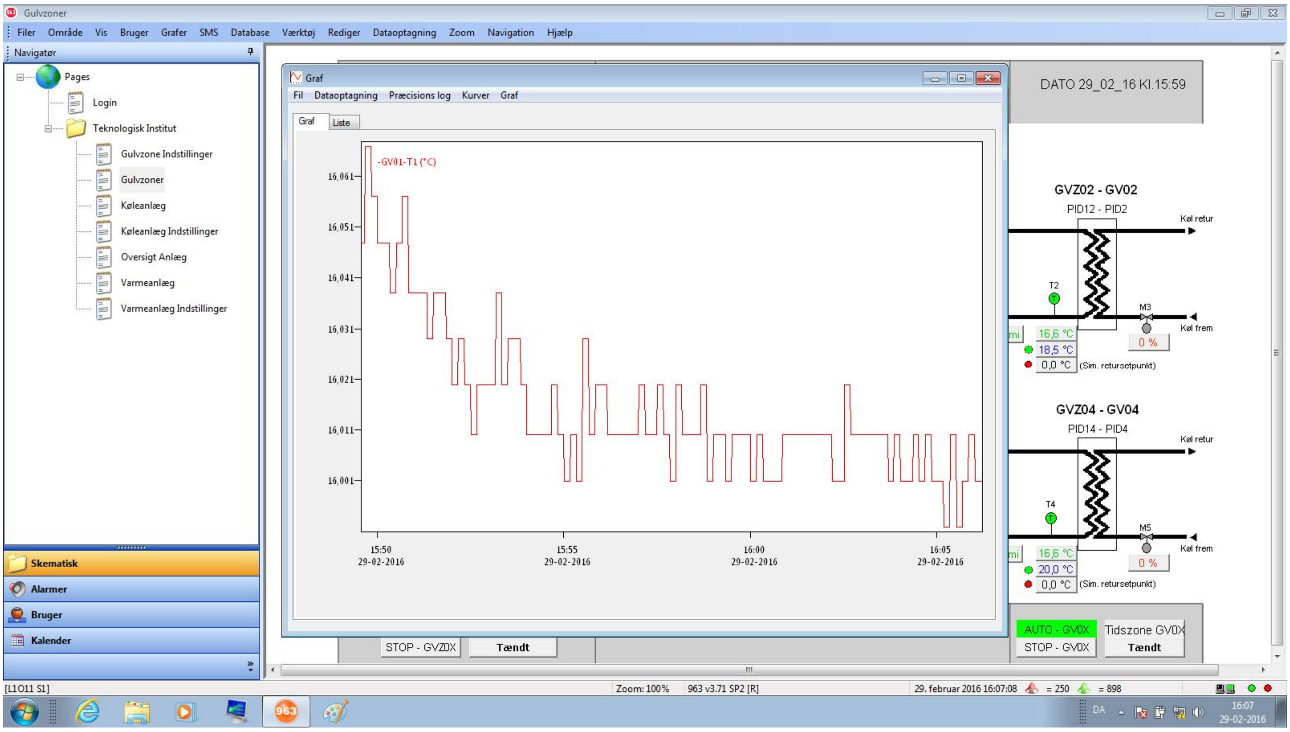


I dette eksempel vælges 20 °C. klik "OK" og værdien skifter, se næste billede.

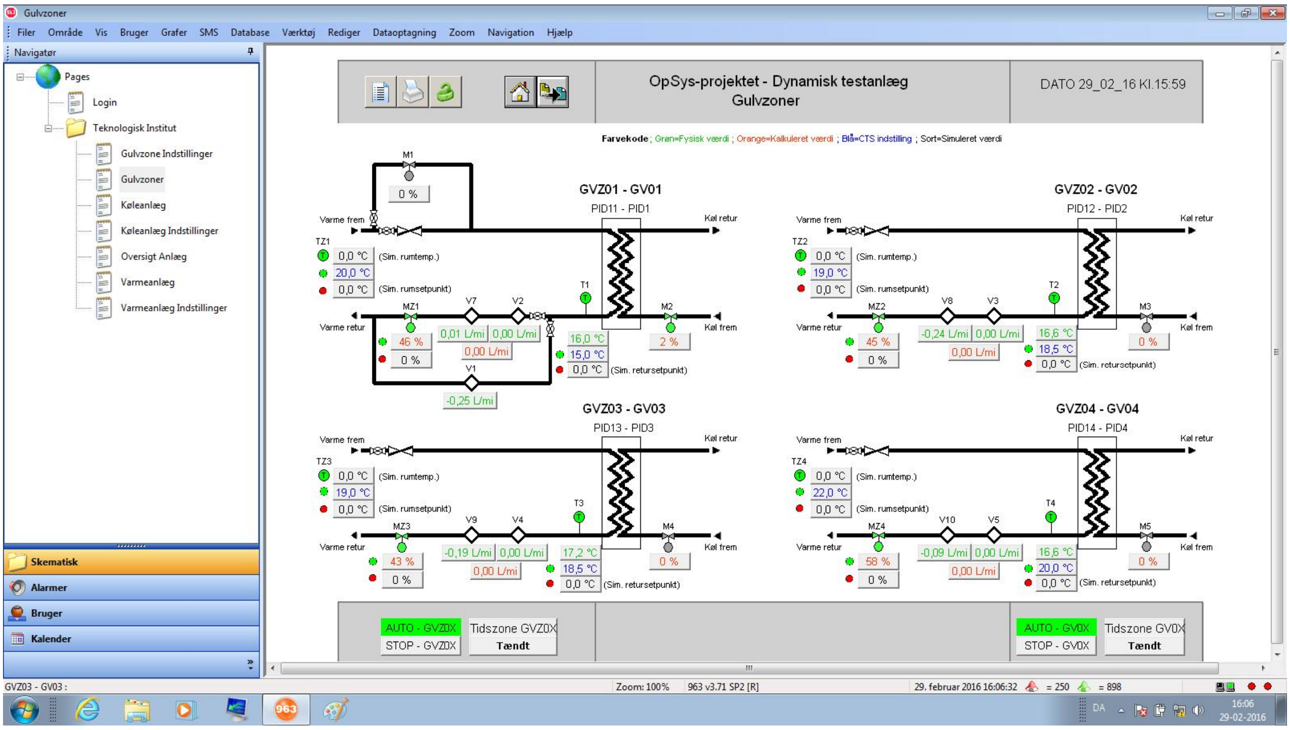


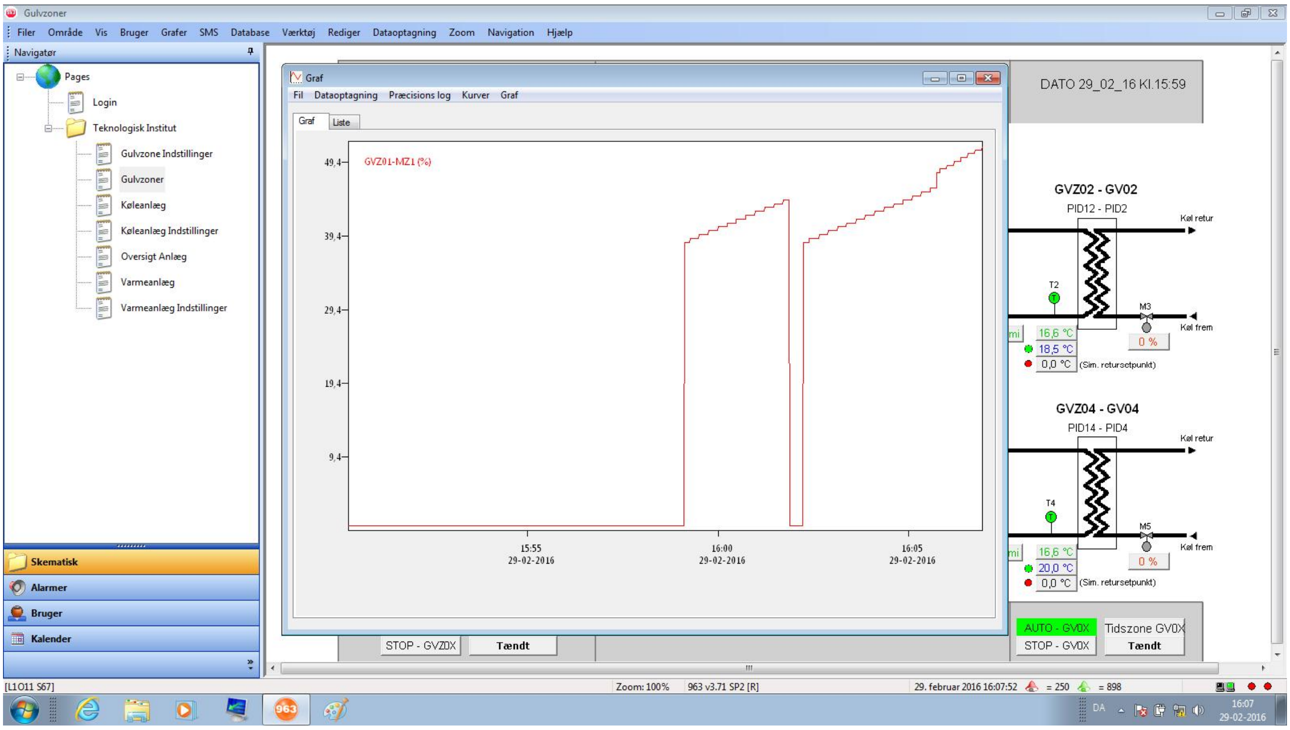
For at se en graf for temperatur føleren T1 klik på knappen med grøn skrift



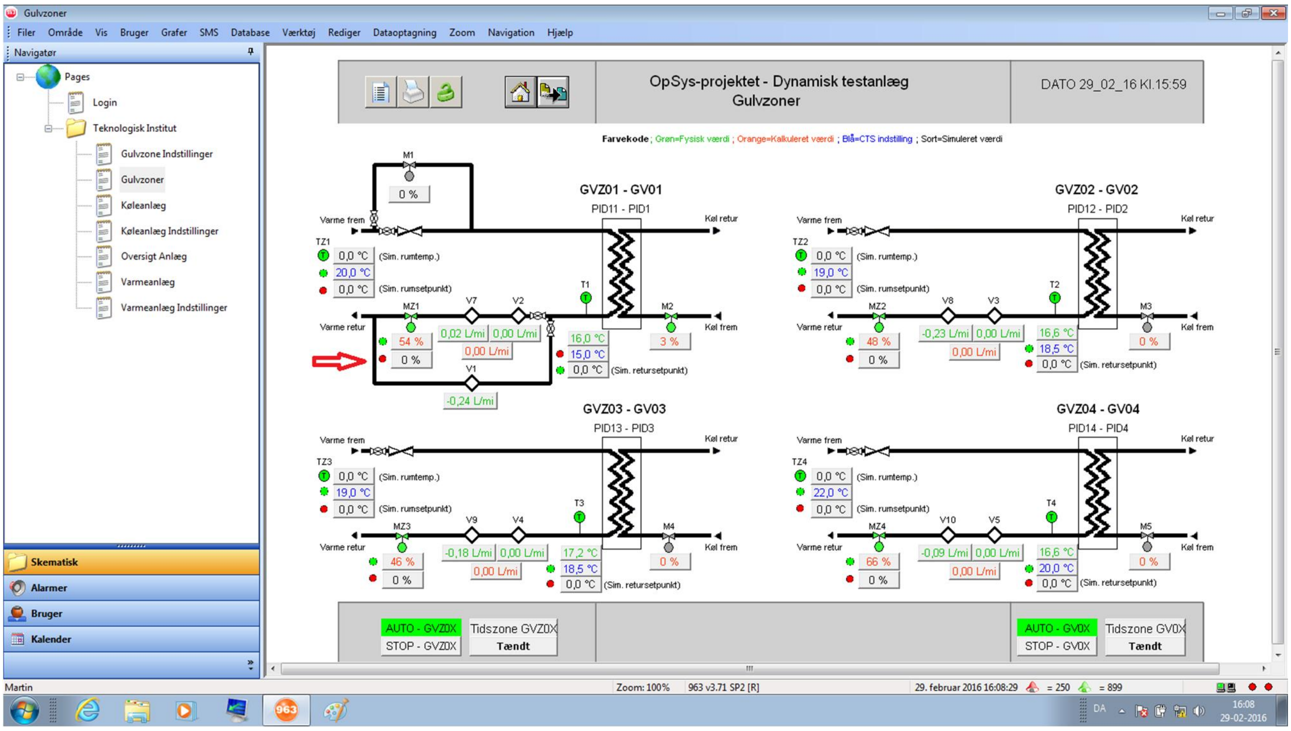


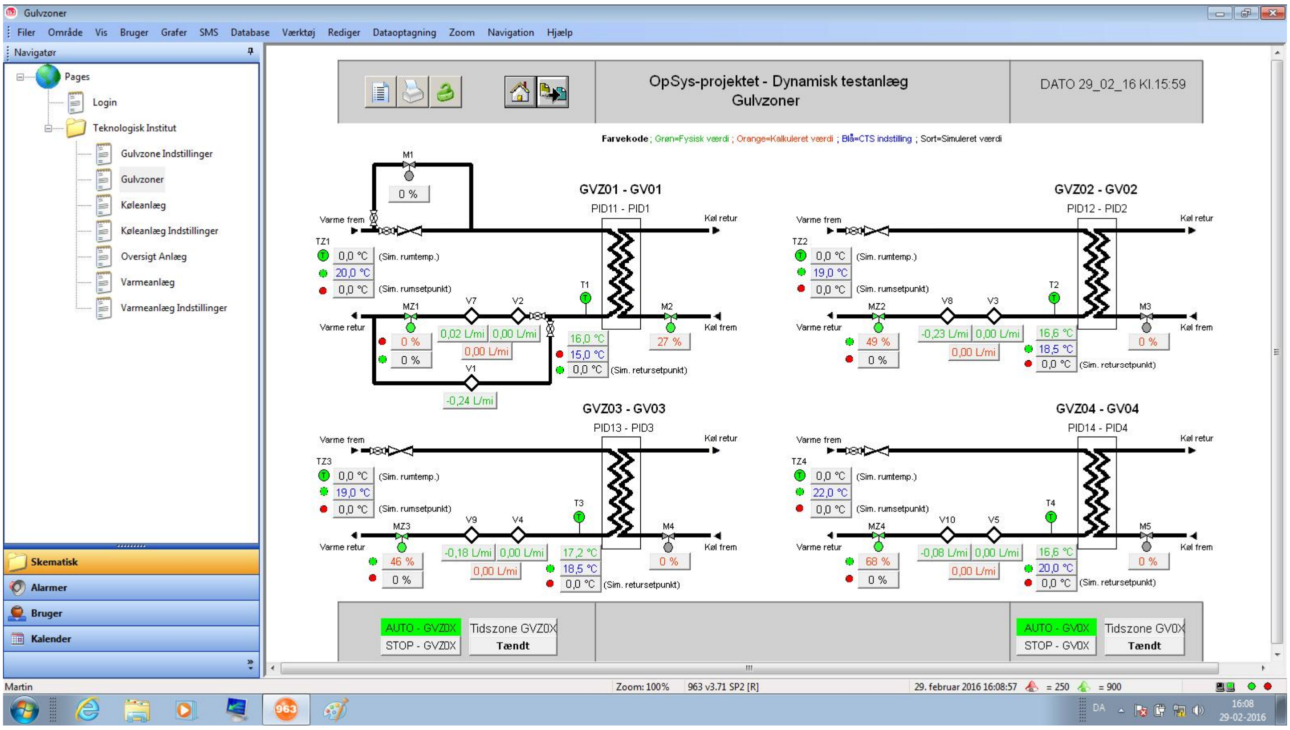
For at se en graf for Motorventil MZ1 klik på knappen med Orange skrift



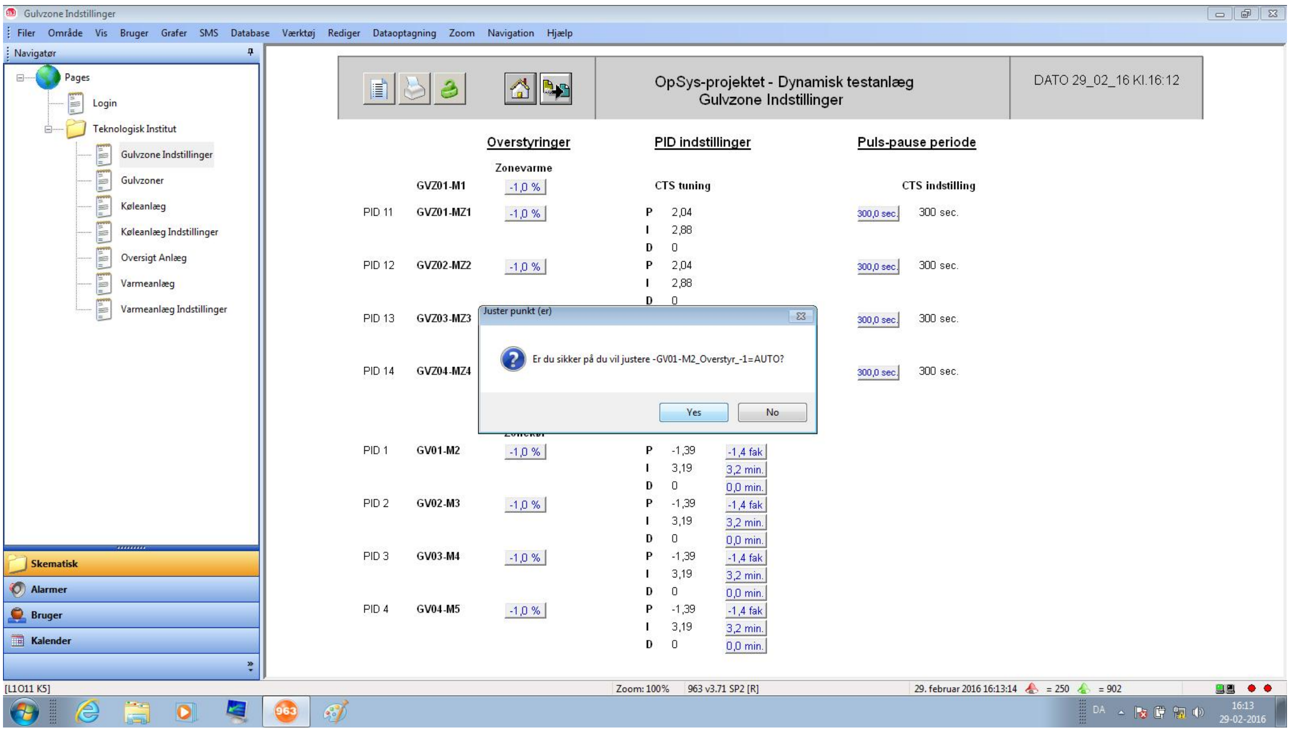


For at styre MZ1 simuleret tryk rødt fælt ved ventil.

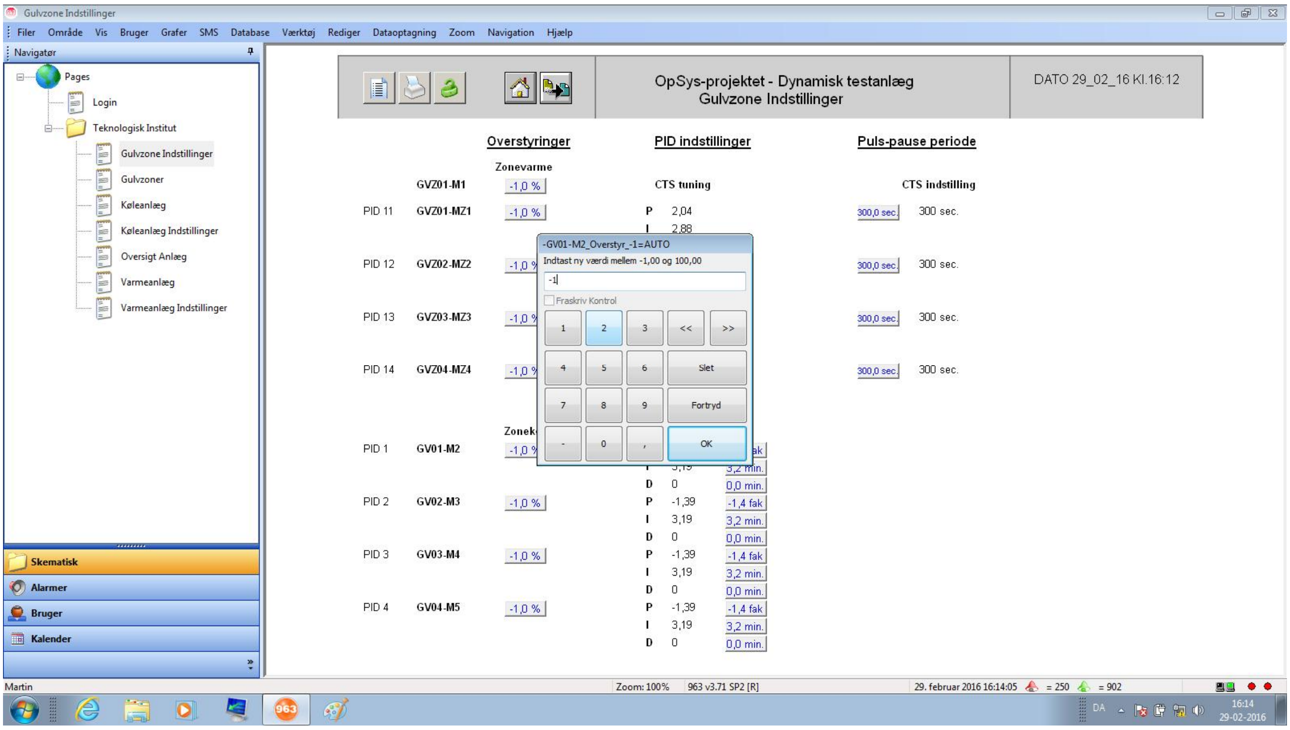




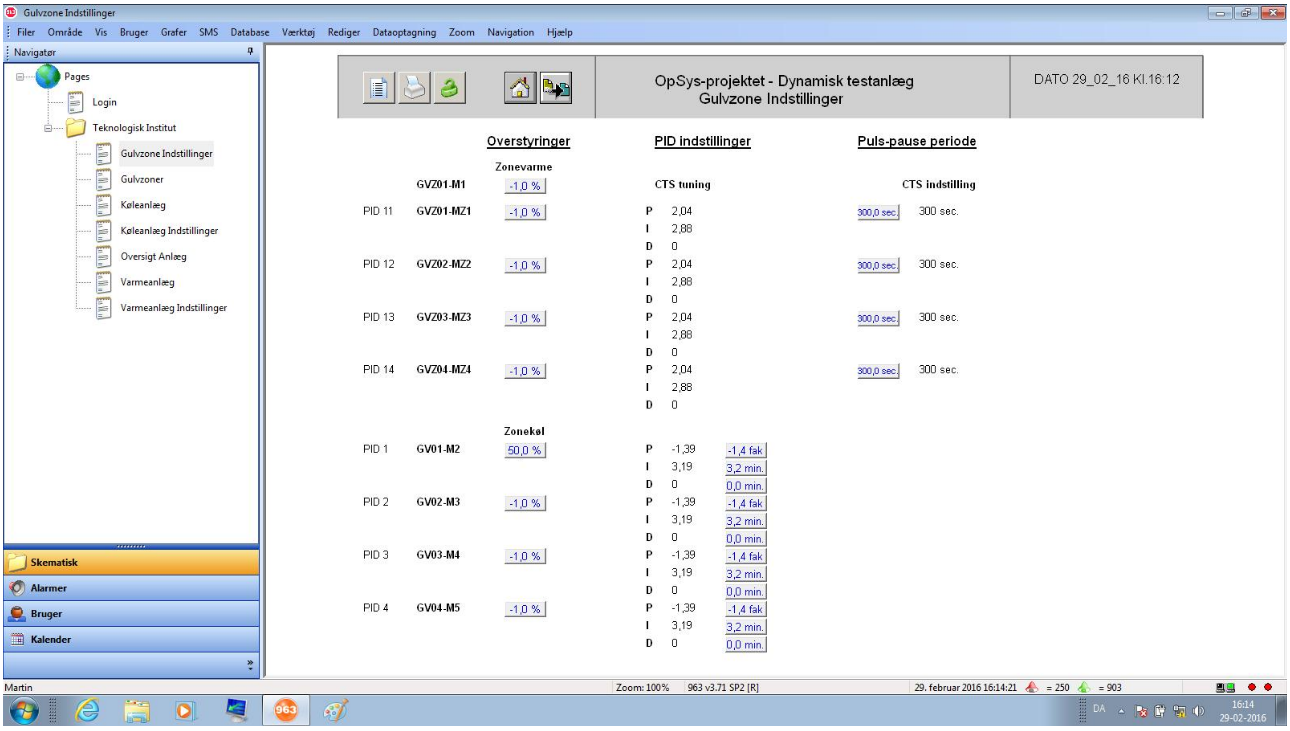
Overstyring af motorventil M2, gå på gulvvarme indstillinger



Tryk på knap med blå skrift for GV01-M2

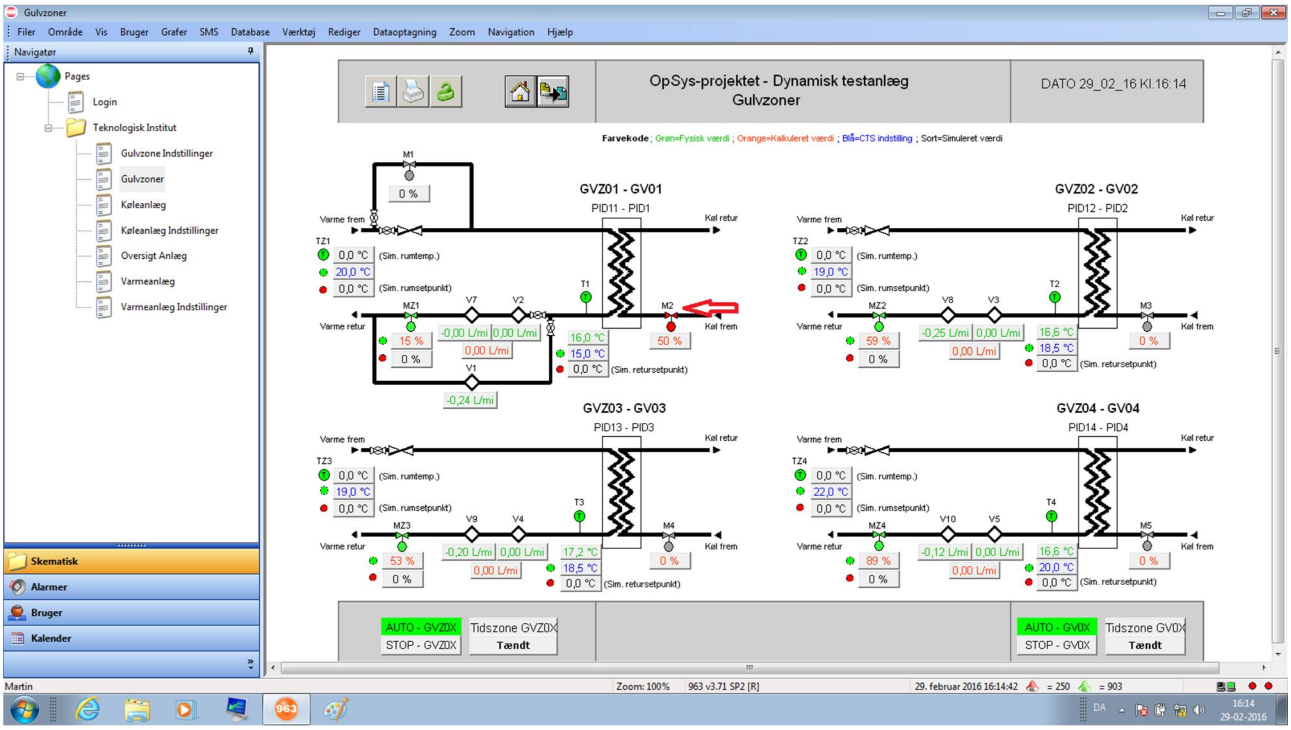


Der kan indtastes værdi fra -1 til 100%, -1 = Auto, 0 til 100% er den ønskede stilling.

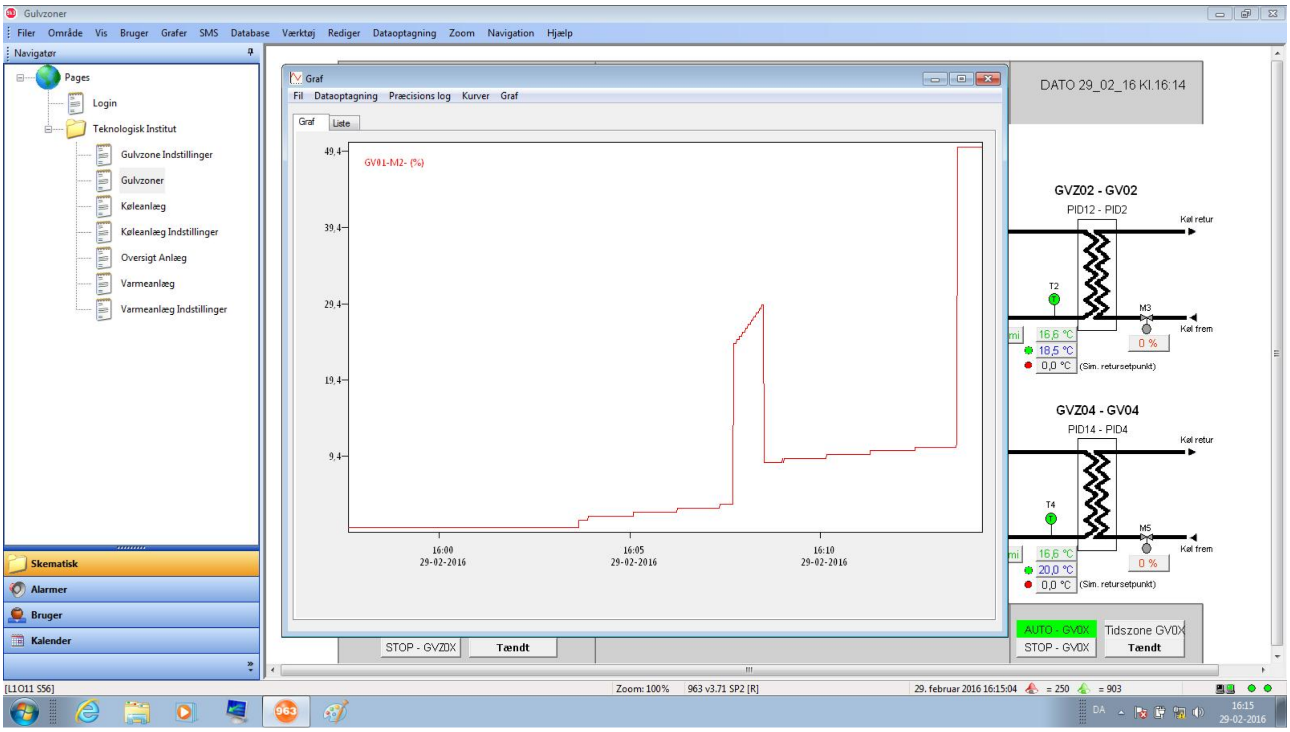


For eksempel 50%

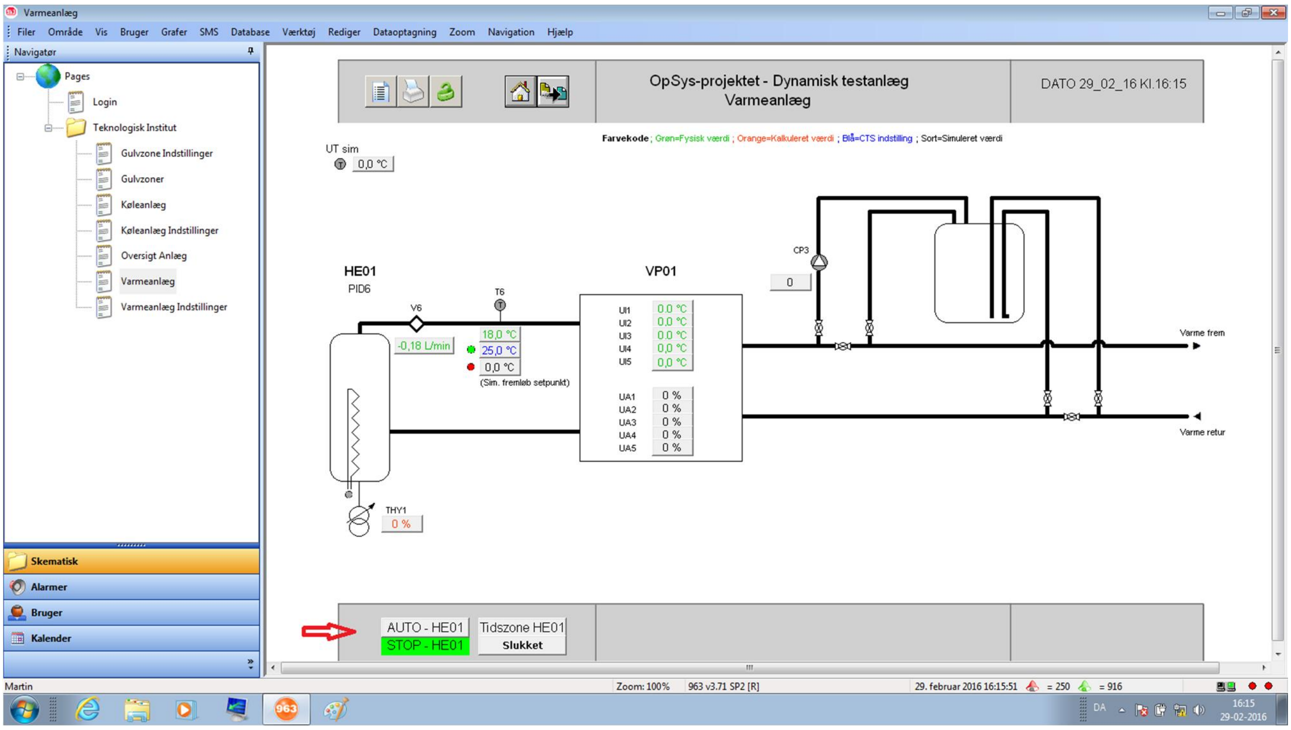
Symbol for ventil bliver rødt som tegn på den er overstyret.



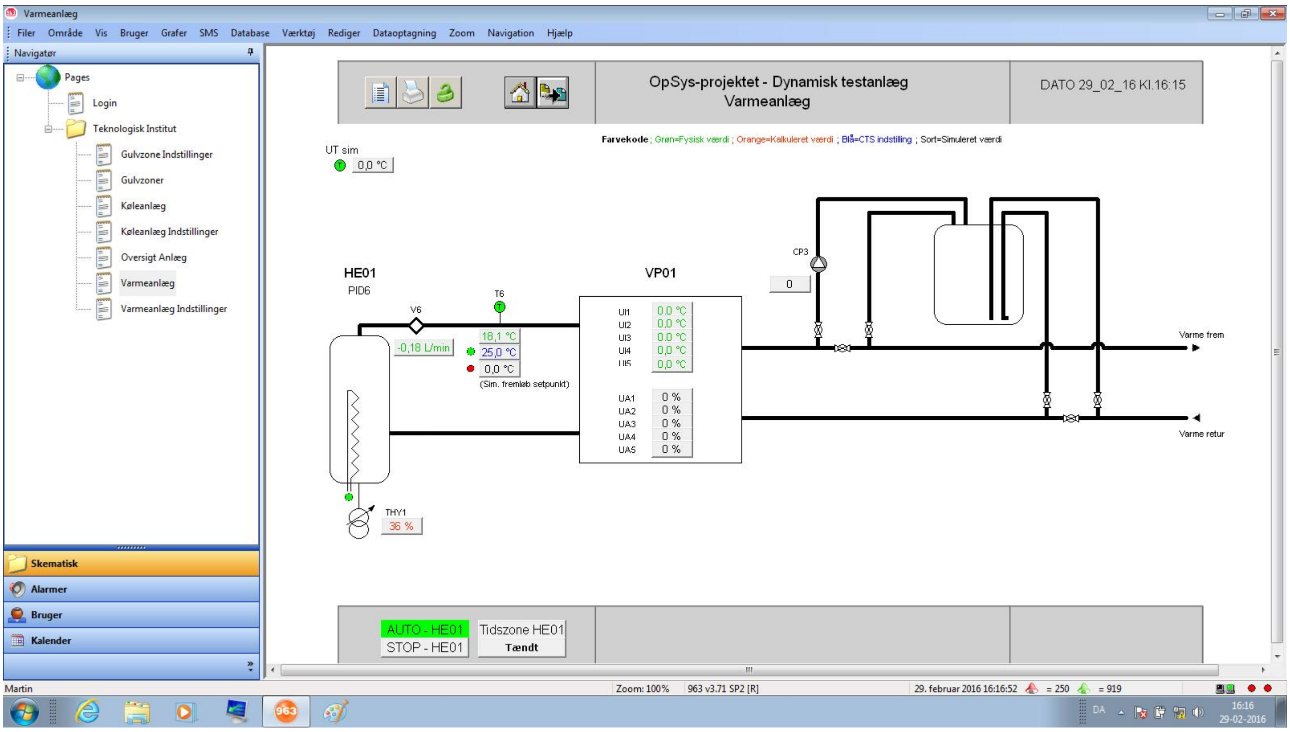
Det kan ses på grafen ved at trykke på knap under ventilen.



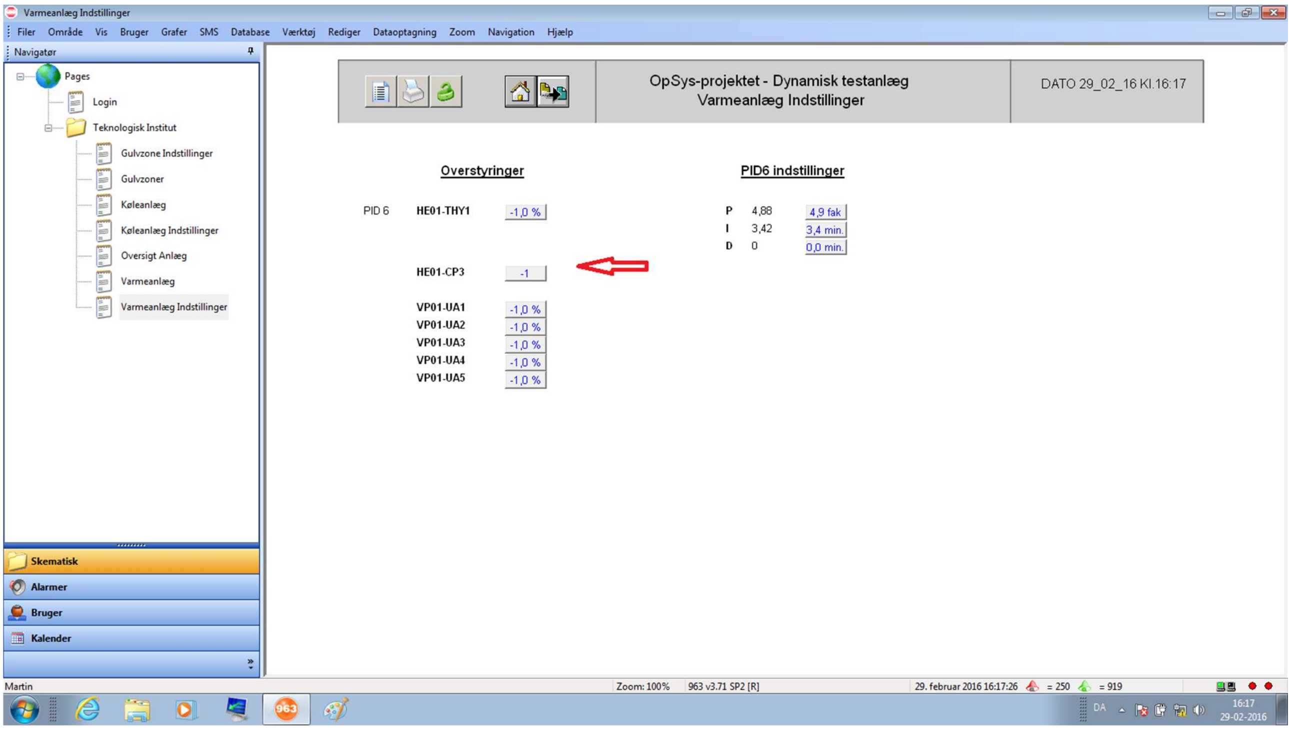
Opstart af varmesystem.



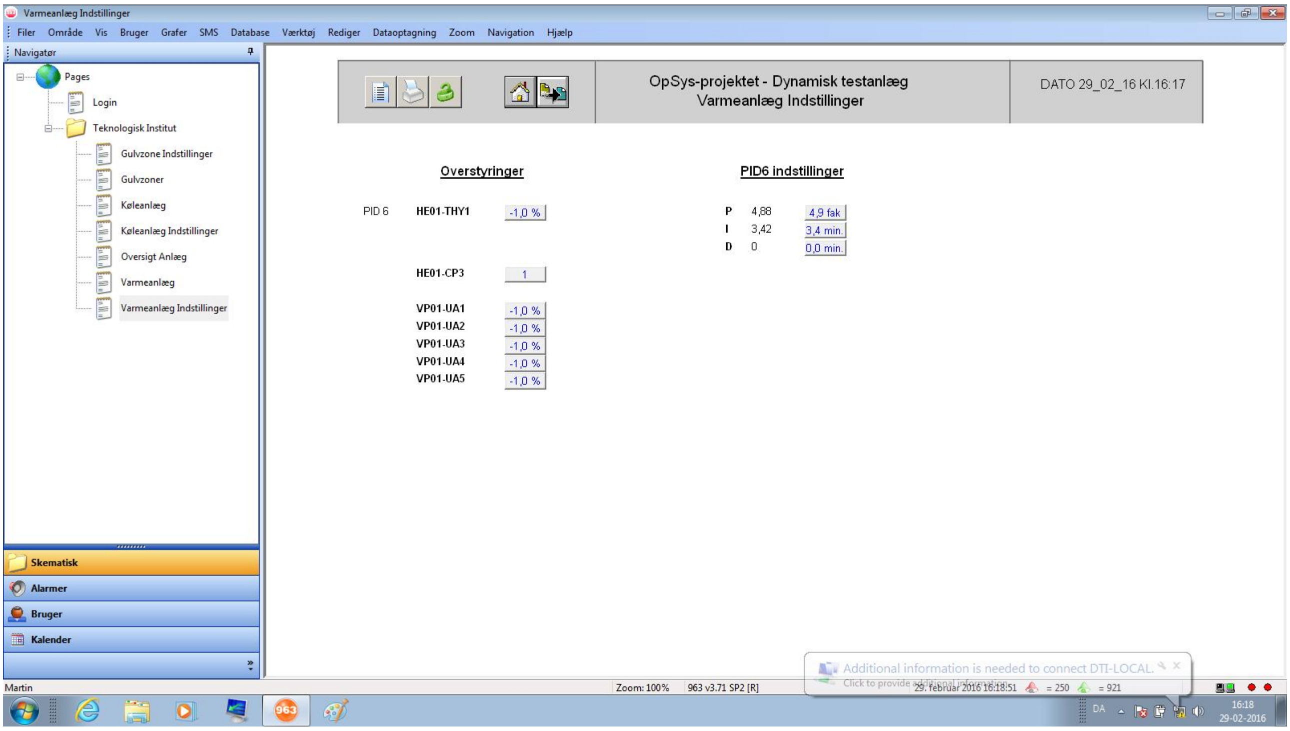
Tryk AUTO-HE01

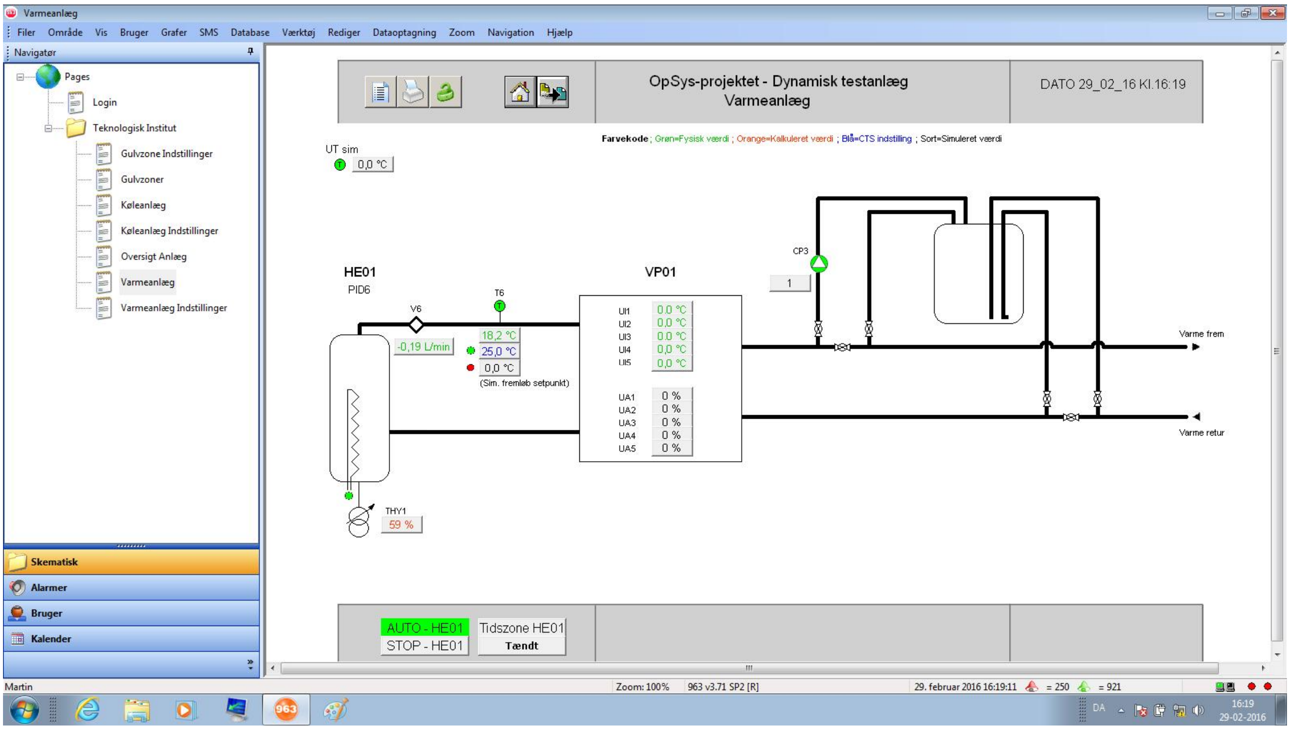


Overstyring af CP3



Der kan indtastes værdi fra -1 til 1, -1 = Auto, 0 til 1 stop og kør.





Varmeanlæg
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Navigatør
Pages
Login
Teknologisk Institut
Gulvzone Indstillinger
Gulvzoner
Køleanlæg
Køleanlæg Indstillinger
Oversigt Anlæg
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Alarmer
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Kalender
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STOP - HE01
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