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Energy efficiency in building automation and control, overview

Class A applications

Application architecture for class A applications

Benchmarking overview

Benchmarking AirOptiControl and Economizer tx2

Energy efficient applications: Heating and refrigeration

Energy efficient applications: Bentilation and air conditioning

Literature

Building simulation, background knowledge

Application positioning

-> BAU strategy

AirOptiControl: Belimo Fan Optimizer, Bauer optimization

-> Differences, coverage, experiences

Economizer TX2: Storck (VCS) -> Germany only

Energy efficiency in building automation and control

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Motivation behind operating a building in an energy efficient manner: What is driving us?

- Standards/regulations/certifications
- Siemens driver “energy efficiency”
  i.e. the belief that you can offer the customer added value if it achieves the desired comfort in a energy and cost optimized manner and, especially, if it documents responsible handling of energy (Interview with Stepahn Bauer “Energy savings potential in buildings is a long way from be tapped”, Fraunhofer press release “Green air – The breath of buildings”)

Standards/regulations/certifications:

- EN 15232 “Energy efficiency in buildings – Impact of building automation and control", energy efficiency classes A, B, …
- National regulations
- eu.bac certification

Introductory documentation at Siemens IC BT CPS: (Term: energy efficiency p.10)

- Applications manual heating and refrigeration supply
- Applications manual ventilation and air conditioning

Applications manual heating and refrigeration supply -> Overview of functions, for example, TABS, PredCtl

Applications manual ventilation and air conditioning -> Overview of functions, for example, AirOptiControl (manual presently being completed)

Applications manual ventilation and air conditioning

p.8: last section (hope this statement can be proven)

p.9: Building automation influence on energy efficiency in four fields: plant control with efficient algorithms / monitoring / support user behaviour with appropriate HMIs / maintain room quality with least energy consumption

p.10: Term: energy efficiency

p.11: Standards, directives

P13: Principles of energy-efficient operation

p.14: Requirments for energy-efficient control

p.15: plant structure

p.20: Demand control

p.28: conventions

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Class A applications

EN15232

As per EN15232, class A applications operate a plant based on demand.

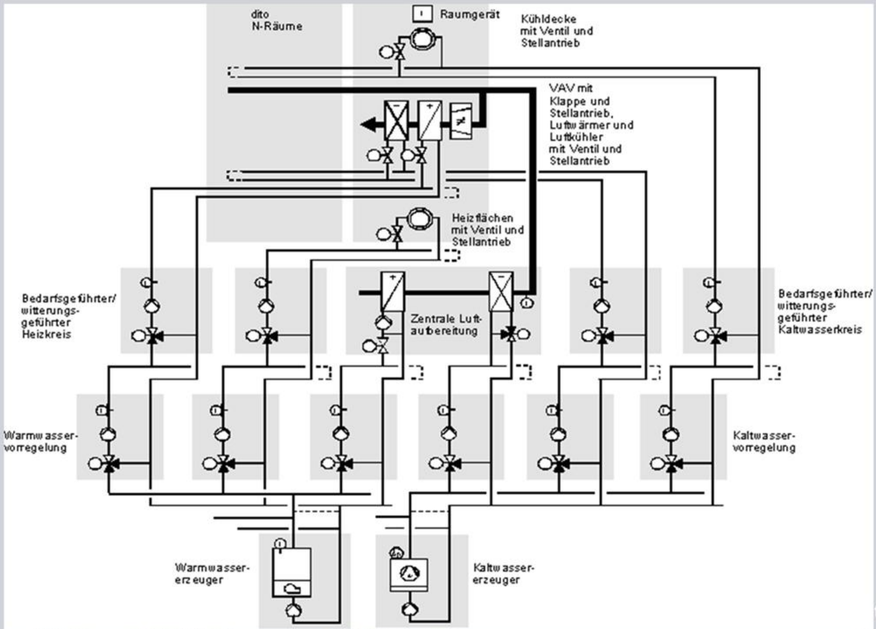
Implementation in Desigo

The Desigo CAS Library supports demand-oriented plant operation:

- Applications architecture with coordinator for demand-dependent control
- Implementation of the application architecture in the Desigo CAS Library
- Variants in the Desigo CAS Library support class A applications

Caution: Not all variants are class A. Some are solutions below that level, for example, supporting scheduled operation.

Application architecture (I): Overview



te vorbehalten.

Application architecture(II): Demand-dependent control

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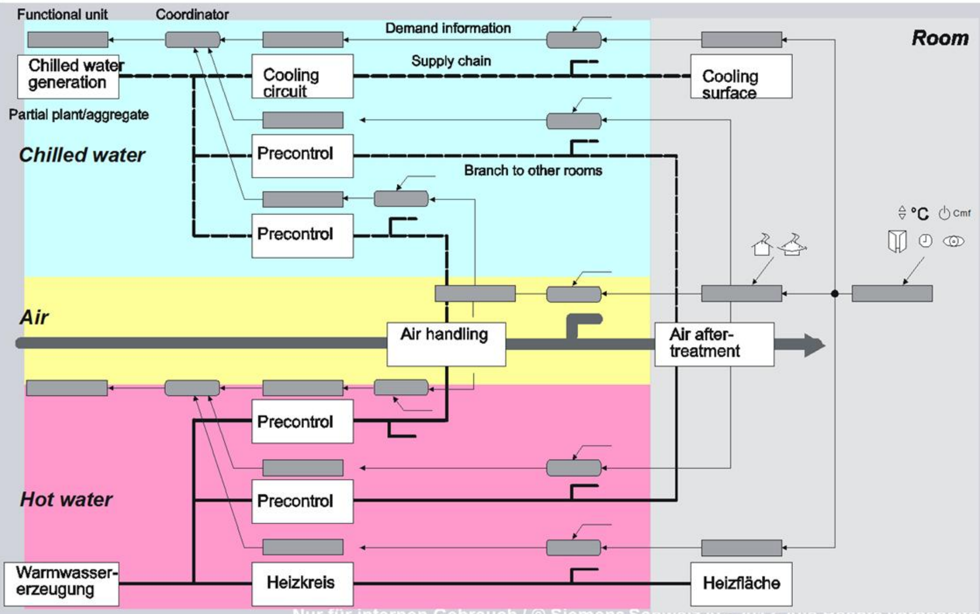

Application architecture (III): Implementation in the Desigo CAS Library

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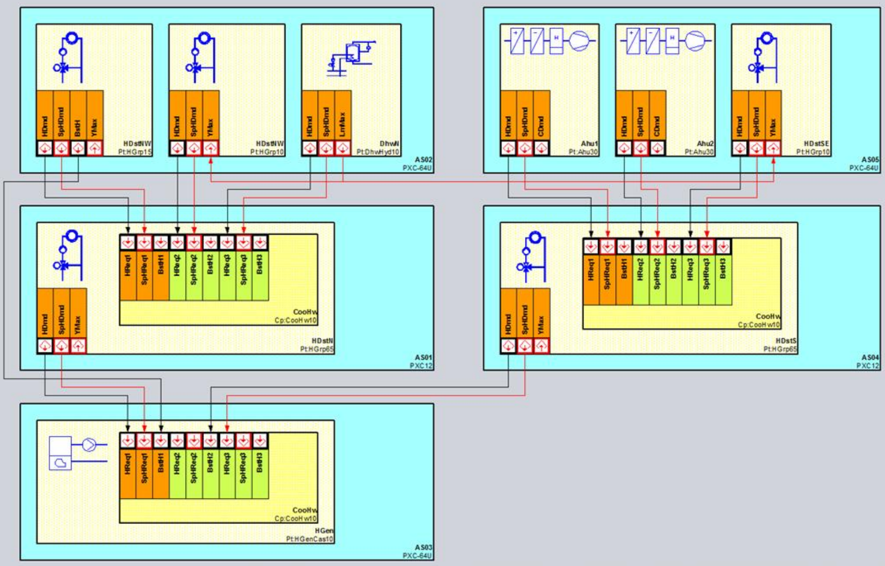
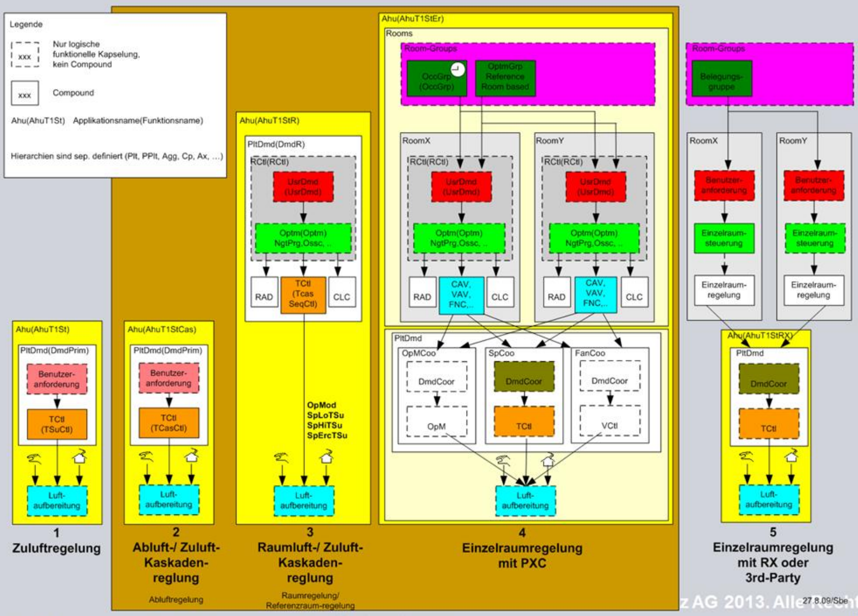


Application architecture (IV): Forming variants in the Desigo CAS Library



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Benchmarking overview

- Benchmarking has not been carried out systematically für all energy efficient application. Only for some A/A+ applications it has been done but for some the benchmark might have improved

- Only the most sophisticated applications (A+) got benchmarked:

- AirOptiControl (up to 50%)
- Economiser tx2 (>10% ... 30%, depending on benchmark plant operation and type of ERC)
- TABS control (up to 75%, depending on benchmark plant operation and benchmark system)
- Predictive heating control (OSSC plus heating release plus heating curve)
- OSSC (>10% ... 30%, depending on benchmark plant operation and type of building)

See also Leporello „Desigo Geprüfte Applikationen – nachhaltig energieeffizient“

Benchmarking: Be careful about what is being compared

AirOptiControl

Air volume optimization -> Room shut down, energy efficiency control mode (high/low supply air temperatures, humidity, AQ)

Pressure optimization/coordination -> Damper position

Temperature optimization/coordination

(humidity optimization/coordination

Air quality optimization/coordination

Bauer optimization

Product at BAU since approximately, mid-2012, no longer at CPS

Reduction to air volume

•High, or low supply air temperatures

•Ventilation efficiency (undirected flow) caused by room overpressure/pressure variants

Lower room temperature setpoints

•Smaller room air velocity

-> Air only plants, room pressure sensors, AQ sensors, VSD fan, adapted air outlets

-> Controversially discussed

Belimo Fan Optimizer

Pressure optimization

•VAV damper positions

Convetional control (CAS application)

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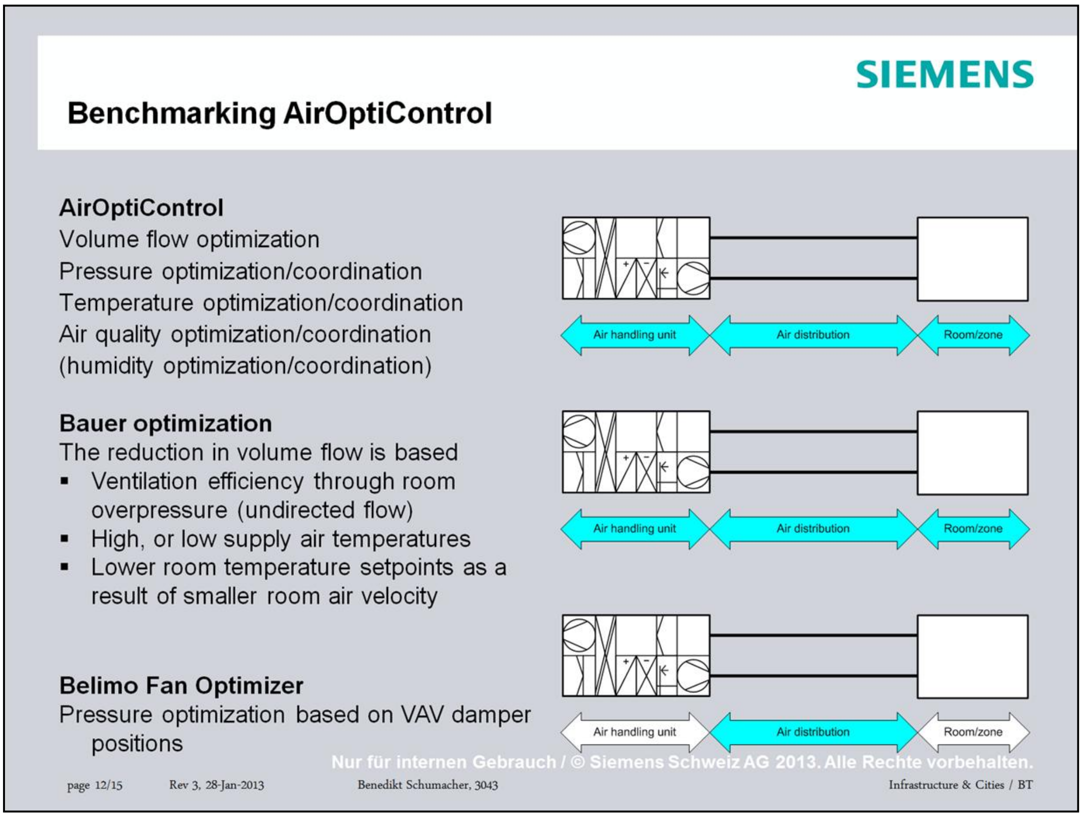
Benchmarking using simulation

- Benchmarking using simulation places high demands on model quality
- The relevant flows must be considered in the required accuracy

-> sep. slides



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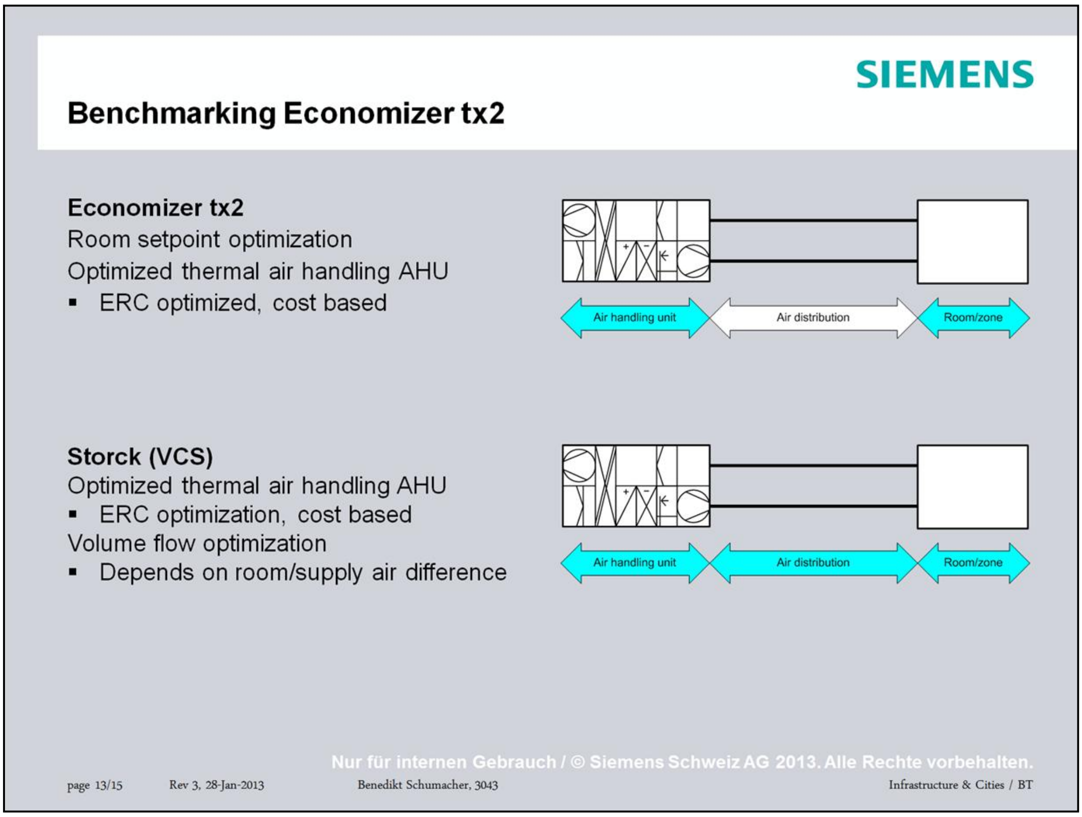

Storck

Volume flow control not suitable for comfort plants with personal occupancy

Strategy sub-volume of tx2

Precision of measurement after mixing air damper is questionable

Convetional control (CAS application)

Energy efficient applications: Heating and refrigeration

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Applications manual heating and refrigeration supply

Energy efficient applications:
Ventilation and air conditioning

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Applications manual ventilation and air conditioning

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Documentation (I)

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Plant control
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Documentation (II)

- Energy efficiency in building automation and control
  Application manual ventilation and air conditioning
- Energy efficiency in building automation and control
  Application manual heat and refrigeration supply
- Desigo
  Tested application – Sustainably energy efficient
  Order number: 0-92232en
- Desigo – Energy efficient applications: h,x-control Economizer tx2; Application datasheet – Siemens Building Technologies, order number: CM110745en-TX2
- Desigo – Energy efficient applications: AirOptiControl; Application datasheet – Siemens Building Technologies, Order number: CM110745en
- Desigo – Energy efficient applications: Predictive heating controller; Application datasheet – Siemens Building Technologies, order number: CM110745en
- Desigo – Energy efficient applications: TABS Control; Application datasheet – Siemens Building Technologies, order number: CM110745en

- www.siemens.com/energieeffizienz
- http://www.buildingtechnologies.siemens.com/bt/global/de/energy-efficiency/Seiten/Energy-efficiency.aspx

Predictive Heating Control

Forward-looking, self-learning, heating control

DESIGO – Energy efficiency applications

RC-SE, December 2012

Markus Gwerder
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Building Technologies Division
Control Products & Systems
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Text

Predictive heating control
Contents

- Predictive (forward-looking) control at Siemens (L&S, L&G)
- Introduction of predictive control
  - Concept
  - Application heating control
  - Conventional weather-dependent heating control
  - Predictive heating control
- The Siemens BT predictive heating control solution in Desigo
  - Delivery
  - Application and goals
  - Function conventional and predictive heating control
  - Comparison of simulations of conventional and predictive heating control
  - Benefits
  - Measured results from test buildings
- Demo (Matlab/Simulink simulation)
- Questions and discussion

Building Technologies / Department 2


Predictive control at
Siemens

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Predictive control at Siemens

Predictive controls for solar plants (1983-1985)

Together with the ETH Zürich, L&G

Neurobat heating controller (1996-1998)

BFE project, CSEM, EPFL, Sauter, L&S, ...
Solution approaches: Neural networks, fuzzy Logics, dynamic programming

Follow-on project Neurobat heating controller (1998-2000)

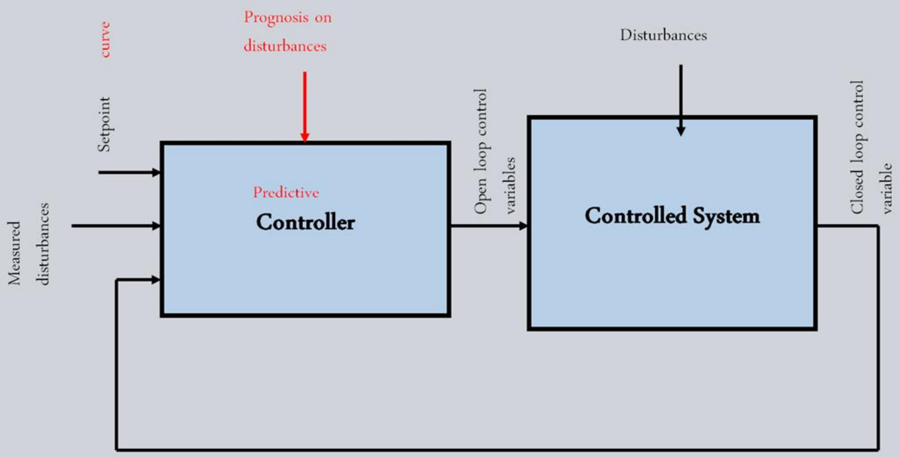
Sauter, CSEM
Goal: Product development

L&S/Siemens activities (1998-2012)

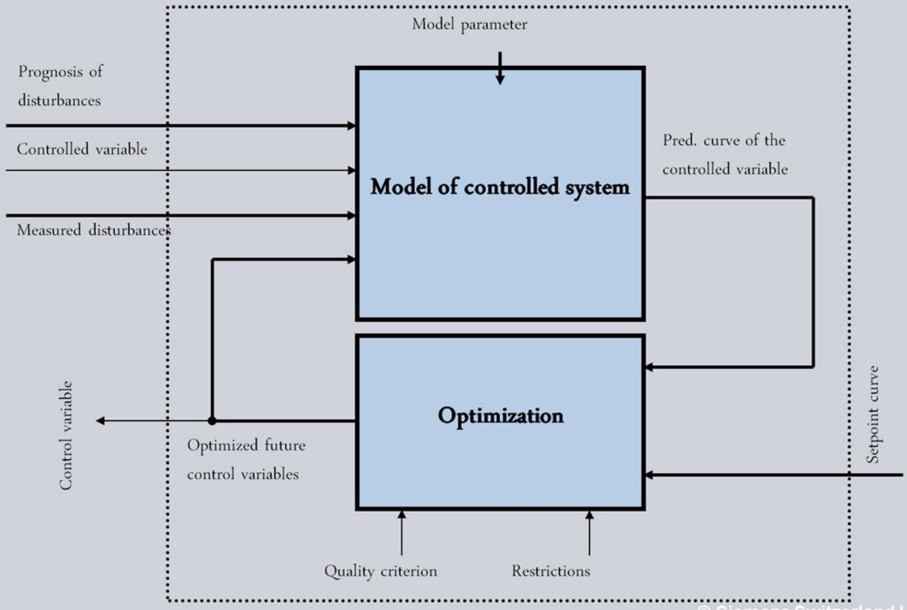
Alternative solution "Predictive heating controller" (End of 1998 – start of 1999)
Patent registration (Summer 1999)
Field testing of predictive heating controller with PC (heating season 1999/2000)
Revised the algorithm for the predictive heating controller (2002/2003)
Field testing of predictive heating controller with Desigo PXC (heating season 2003/2004)
Manual adjustment procedure for predictive heating controller (2003-2005)
Predictive controls in other HVAC applications (2003-2009)
Projects OptiControl-I (2007-2010) and OptiControl-II (2011-2013) (www.opticontrol.ethz.ch)

Text

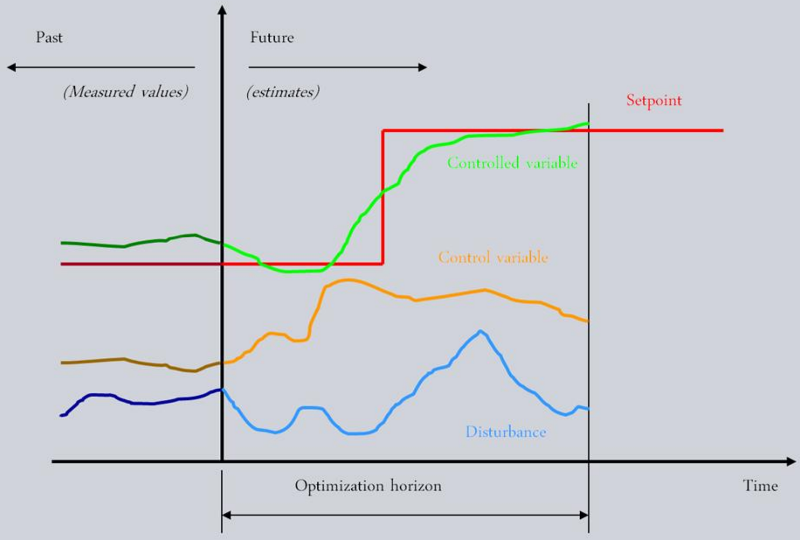
General predictive control
Concept



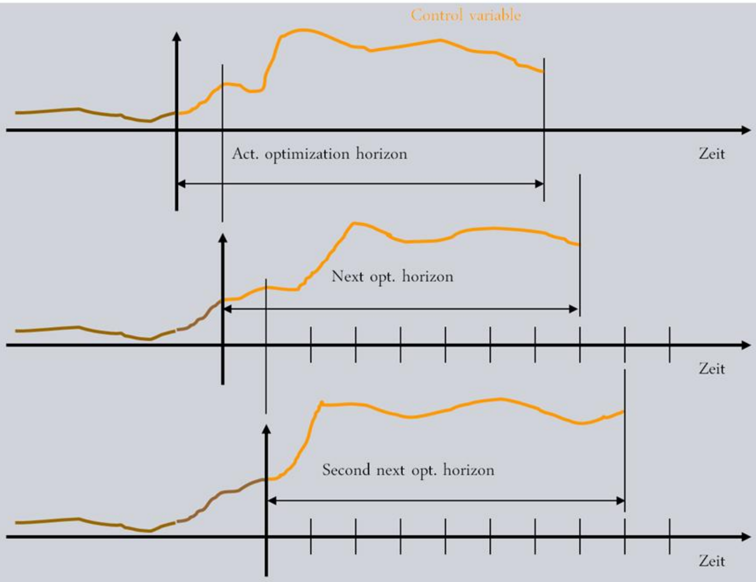
Model predictive control
Concept



Model predictive control
Concept



Model predictive control
Concept



Predictive heating control
Application

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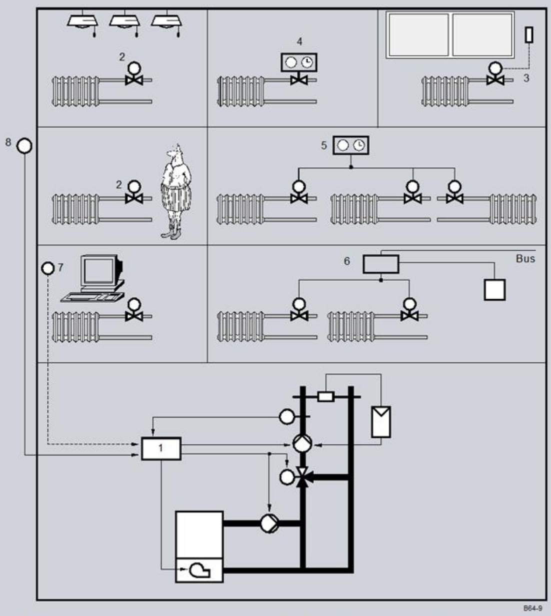

1. Central heating circuit controller
2. Thermostatic radiator valve head (fitted onto radiator valve)
3. Thermostatic radiator valve head with remote sensor
4. Radiator valve fitted with electronic valve head
5. Radiator valve with actuator and time-programmed room temperature controller
6. Individual room controller with room unit (as part of a building automation and control system) acting on several radiator valves with actuators
7. Room temperature sensor in reference room (for room influence)
8. Outside air temperature sensor (and possibly other sensors for solar and wind influence)

Text


The Siemens BT
predictive heating control
solution in Desigo

Predictive heating control
Desigo

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Implementation of the solution as of Desigo V4:
Desigo PXC (automation stations), Desigo Insight (management station)

Page 12 November 21th, 2012 Markus Gwerder Siemens Building Technologies

AP1: Basics

AP1.1 Preparing a simulation tool (including lab trials to validate the model)

AP1.2 Evaluate existing simulation tools

AP1.3 Interaction of TABS with ventilation plants and supplemental systems (deleted)

AP1.4 Examinations on cycle mode

No planned at the start of the project, but quickly concluded:

AP1.x Studies on proceeding in AP2

Various solution approaches developed. Ultimately decided in favor of the solution concept, “Unknown-but-bounded approach”.

Predictive heating control

Delivery Desigo solution

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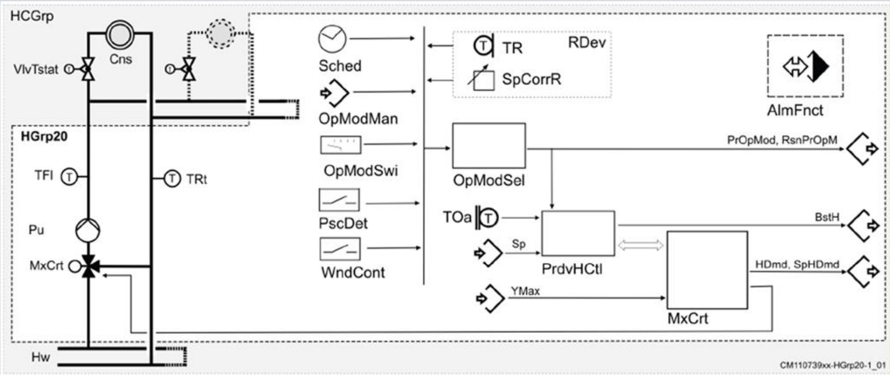

The application predictive heating control is Desigo as of V4.0 includes the following elements:

▪**Compound** {HGrp20}, with associated documentation of the compound libraries
▪**Firmware** Function PRDVHCTL with associated documentation of the firmware library
▪Insight **Super Genies** with associated documentation
Desigo Insight, Contents of Graphics Libraries
Desigo Insight, Manual PX Graphics libraries (Genies/Super Genies)
Desigo Insight, Graphics libraries (Global, PX)

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Predictive heating control

Planned application

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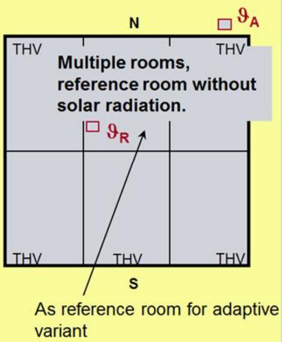
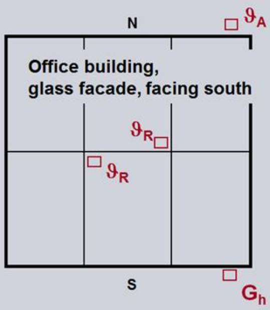
Type 1



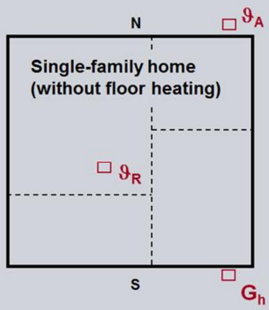
- 1 heating circuit
- without solar rad.sens.

Type 2



- 2 heating circuits for south and northern facade
- with and without solar rad.sens.

Type 3



- Considered as 1 room building
- 1 heating circuit
- with and without solar rad. sensor

Predictive heating control
Goals

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Commissioning
Replace 3 basic functions with 1 function which includes a dynamic building model

Explainable
The control strategy is intuitive and easy to understand

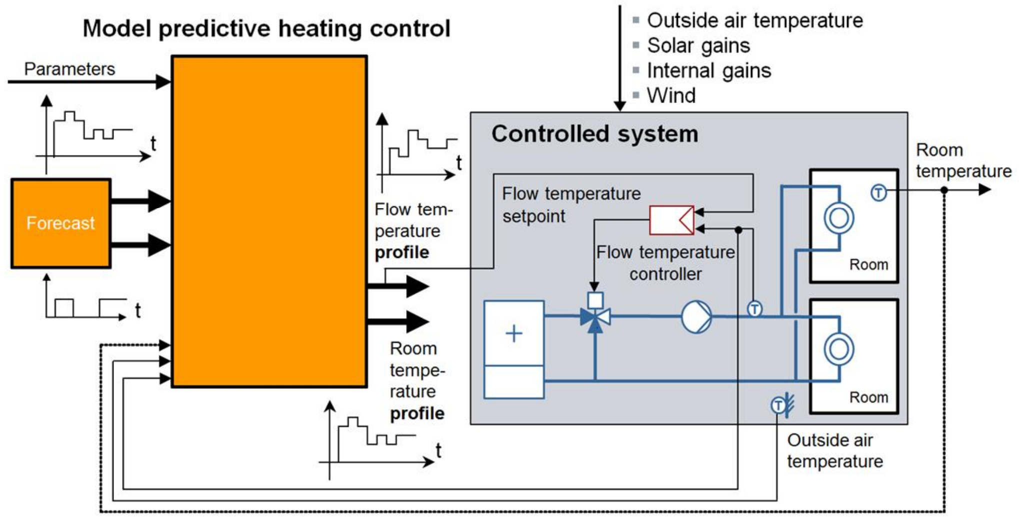
Energy & comfort
Energy savings by minimizing energy consumption while simultaneously maintaining stricter comfort barriers

Proper functioning in all situations
The control properly reacts even to exceptions (faults/compensation behavior)

Innovations and vision for the future
Experiences with predictive heating controllers easy employment of (model) predictive controls for other HVAC applications as well

Development of the first commercially available model predictive controller in building automation and control!

Predictive heating control
Function



Conventional heating control
Function

Main functions of conventional heating control:

- Scheduler program to specify room operating mode
- Heating curve **(HCRV)** for weather-dependent flow temperature control (in addition, an optional room temperate-dependent setpoint adjustment)
- Optimum Start Stop control **(OSSC)** to optimize energy consumption for changes in occupancy
- Heating limit switch **(HRA)** to switch on and off the heating plant during transition periods (spring/autumn)
- Sustained mode function
- PI(D) controller flow temperature

Conventional heating control
Function

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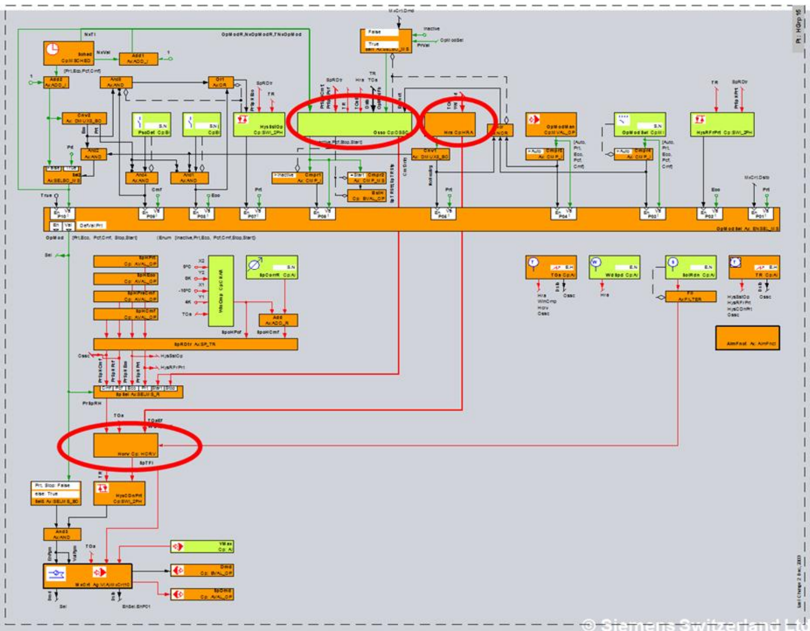

Function

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Main functions of predictive heating controller:

- Scheduler program to specify room operating mode
- Forward-looking/optimizing function **PRDVHCTL** to directly determine the flow temperature setpoint (assumes functions HCRV, OSSC, HRA)
- PI(D) controller flow temperature

Predictive heating control
Function

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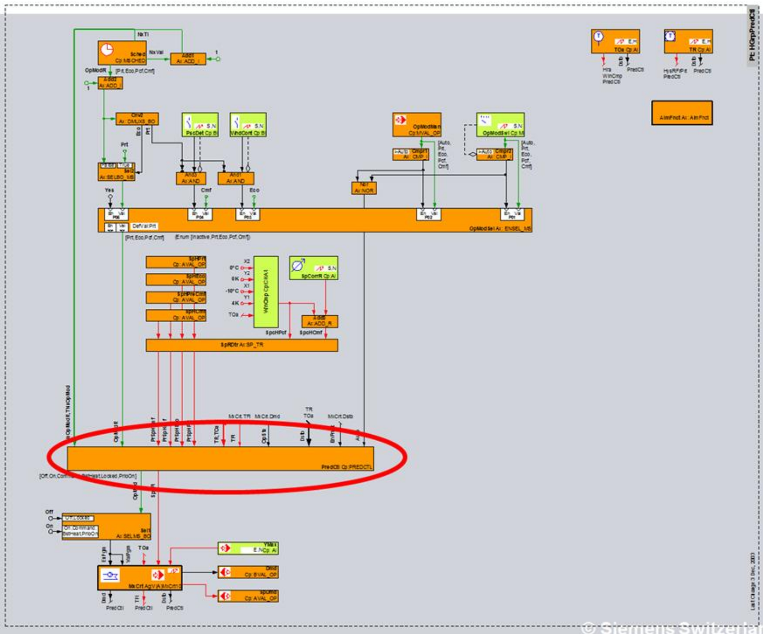

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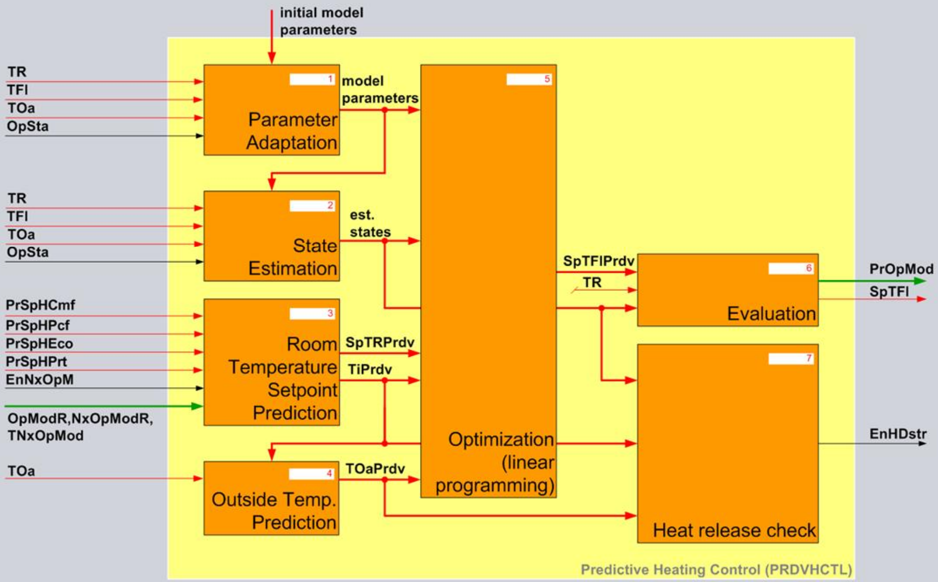
Predictive heating control
Function elements



Predictive heating control
Function – Building model

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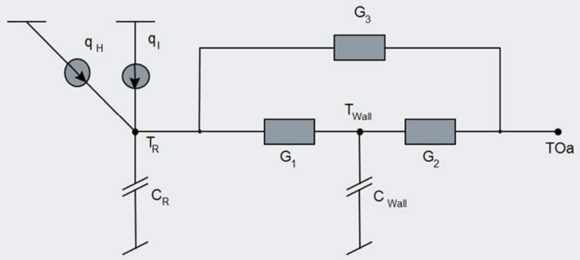
$$\underline{x}_{k+1} = A\underline{x}_k + B\underline{u}_k = \begin{bmatrix} 0 & 1 \\ p_2 & p_1 \end{bmatrix}\underline{x}_k + \begin{bmatrix} p_3 & p_5 & 0 \\ p_4 + p_1 p_3 & p_6 + p_1 p_5 & p_7 \end{bmatrix}\underline{u}_k$$

$$y_k = C\underline{x}_k = \begin{bmatrix} 1 & 0 \end{bmatrix}\underline{x}_k$$

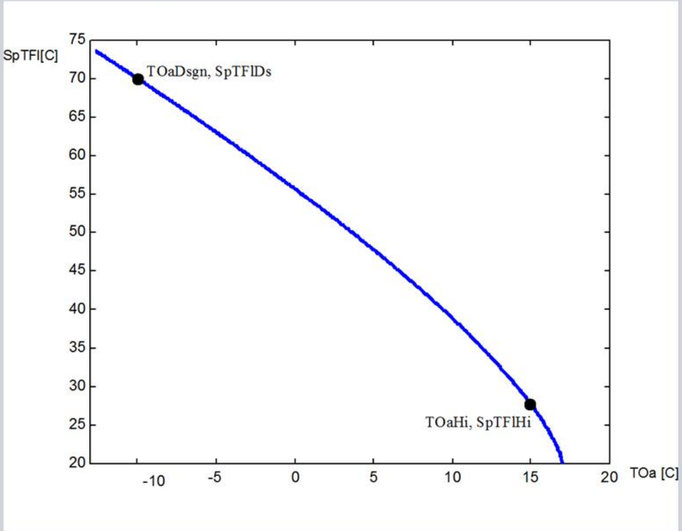


$$\underline{u}_k = \begin{bmatrix} \widetilde{TFl}(k) \\ TOa(k) \\ 1 \end{bmatrix}, \; y_k = TR(k)$$

$$\widetilde{TFl} = (TFl - TR)^{\kappa}$$

Predictive heating control
Function – Building model parameters

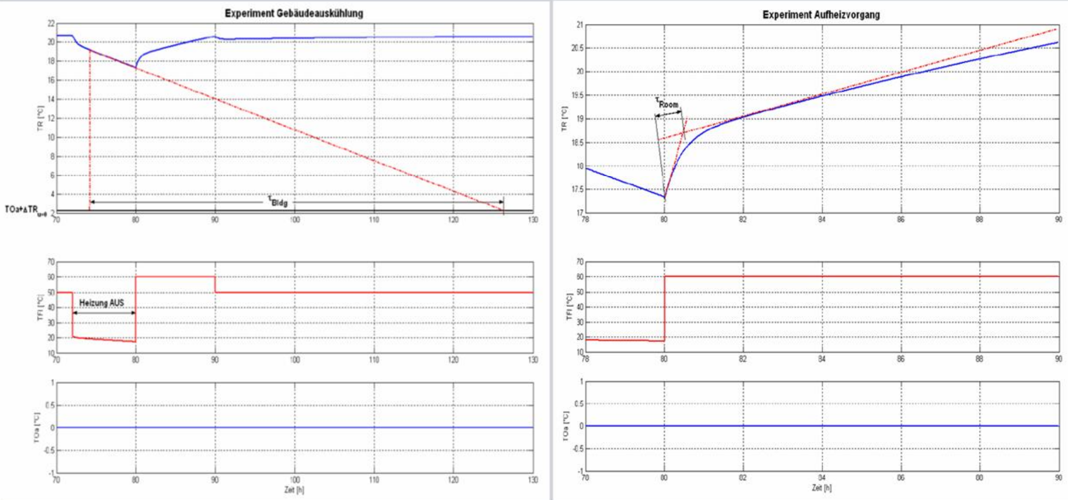
Static: Heating curve



Predictive heating control

Function – Building model parameters

Dynamic: Building cool down time constant, room time constant



Predictive heating control

Function – Building model parameter

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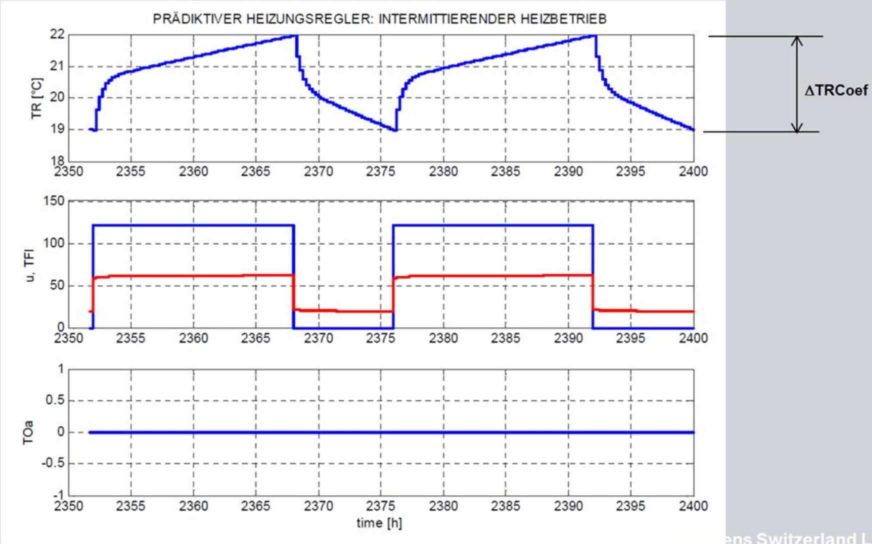
Dynamic: Room temperature difference at intermittent heating operation



Predictive heating control

Function – Building model parameter

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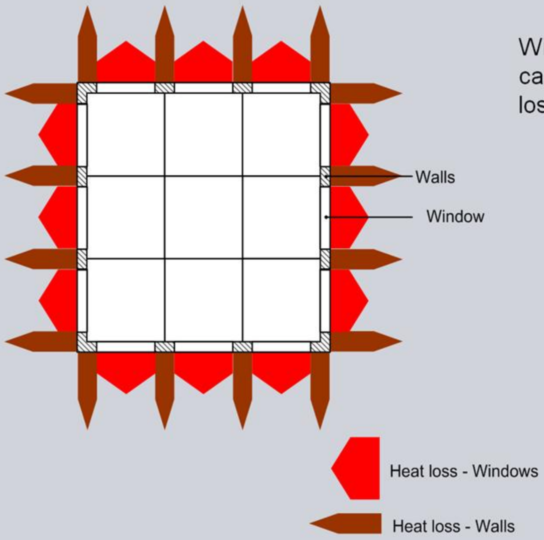
Dynamic: Window ratio



Window ratio: Share of heat loss caused by windows on total heat loss

Predictive heating control

Function - Optimization

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$$\underset{x \in \Re^n}{\text{minimize}} \quad q(x) = f^T x$$

$$(i) \quad A_1 x \le b_1$$

$$(ii) \quad A_2 x = b_2$$

$$(iii) \quad x \ge 0$$

Linear programming to resolve the optimization problem

x
(Transformed) flow temperatures for discrete time on the current optimization horizon

Inequalities (i)
- Limitations to the room temperature to the downside: *TR ≥ SpTR*
- Limitations to the flow temperature to the upside: *TFl ≤ SpTFlMax* + *(TR-SpTRnom)*

Equations (ii)
- non available

Inequalities (iii)
- Limitations to flow temperature to the downside: *SpTFl ≥ TR*

Predictive heating control
Function – After treatment

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Evaluation

Determine the operating mode to the optimized flow temperature profile:

Off	Switch off (pump off)
On	Switch on, not in boost heat or switch-off phase (pump on)
Boost heat	Boost heating (target temperature: SpHCmf or SpHPcf)
Stop	Shut down procedure (target room temperature: SpHPcf)

Heat release check

Determine enable heating output:

If there is no heat output provisioning throughout the current optimization horizon, the comfort criteria cannot be violated, if no heat output is enabled.

Replaces function heating limit switch (HRA)

Predictive heating control

Desigo Implementation

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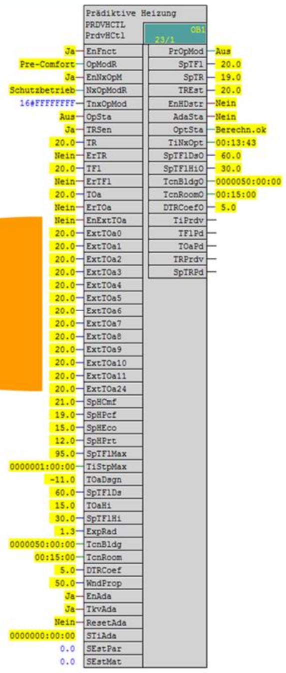
Firmware function (FB)

PRDVHCTL

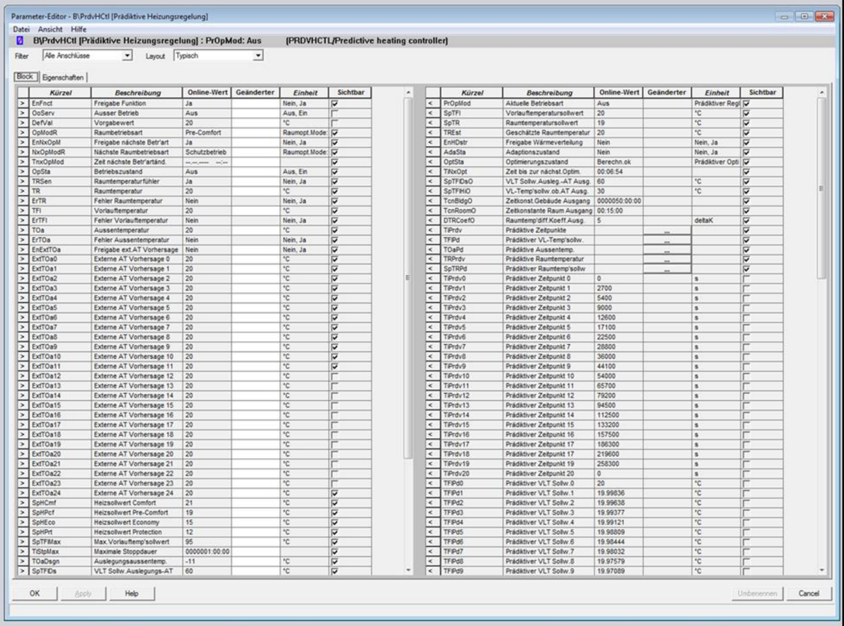
Desigo V4.0: First version

Desigo V5.0: Extended external outside temperature forecast



Predictive heating control
Desigo implementation

Firmware function (FB) **PRDVHCTL**



Predictive heating control
Simulation comparison of conventional versus predictive control I

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Simulated building

- Heat insulation: Swiss average, U value of building exterior shell 1.5 W/(m^2K)
- Window ratio 20 %
- Location: Zurich (SMA), measured data for the 2007
- Heat gains: Low (0 to 30 W/m^2, peak value for strong solar radiation), office occupancy (large office as per SIA 2024)
- Comfort requirements: Room temperature setpoint: Comfort = 21°C, Economy = 15°C
Room operating mode Comfort Monday through Friday from 8 am to 7 pm; otherwise Economy

Control strategies

Predictive heating controller

- Exact simulation of the predictive heating controller function from Desigo V4
- The room temperature measurement is used, the room temperature measurement occurs ideally
- The control is initially **well set** and improves control accuracy even more through the use of an adaptive function in the simulation curve.

Conventional heating control 1

- Simulation of the conventional heating control function with elements heating limit switch (FB HRA), heating curve (FB HCRV) and Optimum Start Stop Control function (FB OSSC). The elements correspond exactly to those from Desigo V4.
The room temperature measurement is used for optimum start-stop control, the room temperature measurement is ideal. The functions OSSC and HRA (heating limit for Comfort: 16.5°C) are **well set**, adaption of function OSSC is switched off.
- The function HCRV is also well set, the heating curve must be increased due to set backs or reduced operation at night to reduce an otherwise insufficient level of comfort (especially in the morning).

Conventional heating control 2

- Simulation of the conventional heating function with elements heating limit switch (FB HRA) and heating curve (FB HCRV). The elements The elements corresponding exactly to those in Desigo V4.
Instead of the optimum start-stop control, the start of Comfort operating mode is advances (Monday: 2 am instead of 8 am, Tuesday through Friday: 6 am instead of 8 am. The function HRA (heat limit for Comfort: 16.5°C) is **well set**.
- The function HCRV is also well set, the heating curve must be increased due to set backs or reduced operation at night to reduce an otherwise insufficient level of Comfort (especially in the morning).

Predictive heating control

Simulation comparison conventional and predictive control II

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	Prädiktive Heizungsregelung (HGrp20)	Konventionelle Heizungsregelung 1 mit Abschaltbetrieb in der Nacht (HGrp15)	Konventionelle Heizungsregelung 1 mit Reduziertbetrieb in der Nacht	Konventionelle Heizungsregelung 2 mit Abschaltbetrieb in der Nacht (HGrp15)	Konventionelle Heizungsregelung 2 mit Reduziertbetrieb in der Nacht
Heizenergieverbrauch: Nutzenergie in [kWh/m^2]	**151**	**156 (+3 %)**	**174 (+13 %)**	**144 (-4 %)**	**174 (+13 %)**
Pumpenlaufzeit Zonenpumpe in [h] pro Jahr (8760 h)	**3081**	**2895 (-6 %)**	**6145 (+99 %)**	**3077 (-0.1 %)**	**6237 (+102 %)**
Komfort: Unterschreitung Raumtemperatur-sollwert in [Kh]	**310**	**644 (+108 %)**	**304 (-2 %)**	**2331 (+652 %)**	**427 (+38 %)**

→ **For the simulated example at well adjusted control, a minimum of 10 % energy savings can be expected through predictive heating control (at comparable levels of comfort)**

Predictive heating control
The combination is your advantage

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Applications

Outside temperature forecast (integrated)

Start / stop optimization

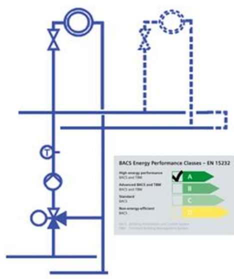
Adaptation of model parameters, include adaptive heating curve

Optimization of flow temperature set point for minimum energy consumption

Model-based prediction of room temperature

Key benefits

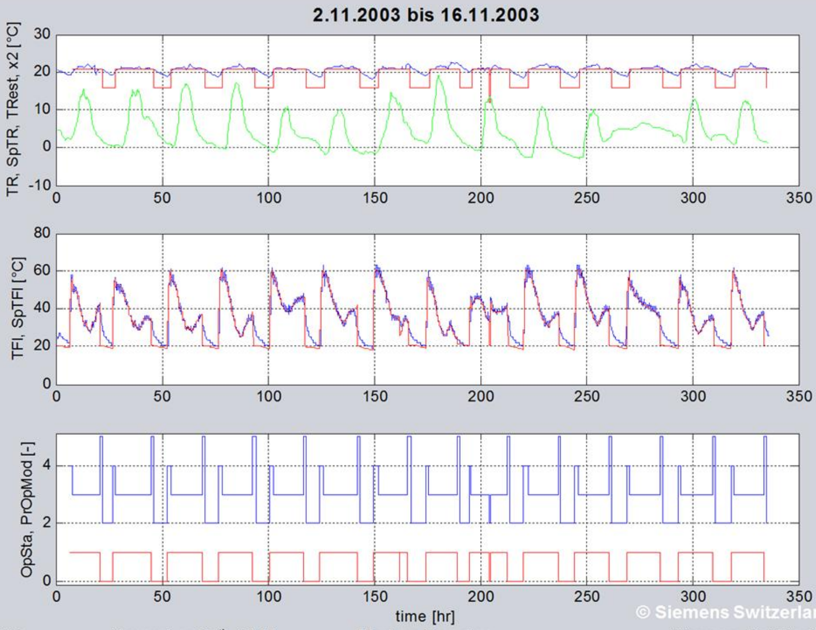
- Cost reduction thanks to energy savings
- Reduced engineering cost thanks to comprehensible control concept
- Reduced commissioning effort thanks to comprehensive functionality with few and simple settings
- High investment protection thanks to standardized, Europe-wide-energy classes
- Shows the innovation power of the companies involved



Predictive heating control
Measuring result from test buildings

Building	Location: Garmisch-Partenkirchen Renovated older building Medium level of thermal inertia	
HVAC technology	Single-stage boiler serves - Hot water - One heating circuit Heat transfer via radiators, flow temperature control via mixing valves, reference room with room temperature sensor (no thermostatic valves in the reference room)	
Data logging	Ca. 25 data points are logged at various scan times (minimum of three minutes) throughout the entire heating season using Desigo Insight	

Predictive heating control
Measuring results from test buildings



Predictive heating control
Measuring results from test buildings

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Building	Location: Schaffhausen Renovated older building Medium thermal inertia 
HVAC technology	Fuel cell with supplemental burner, hybrid solar collector, PV - Hot water - One heating circuit Heat transfer via radiators, flow temperature control via mixing valve Reference room with room temperature sensor (no thermostatic valves in reference room)
Data logging	Logging of ca. 250 data points with various scan times (at least one minute) with Desigo Insight

Predictive heating control
Measuring results from test buildings

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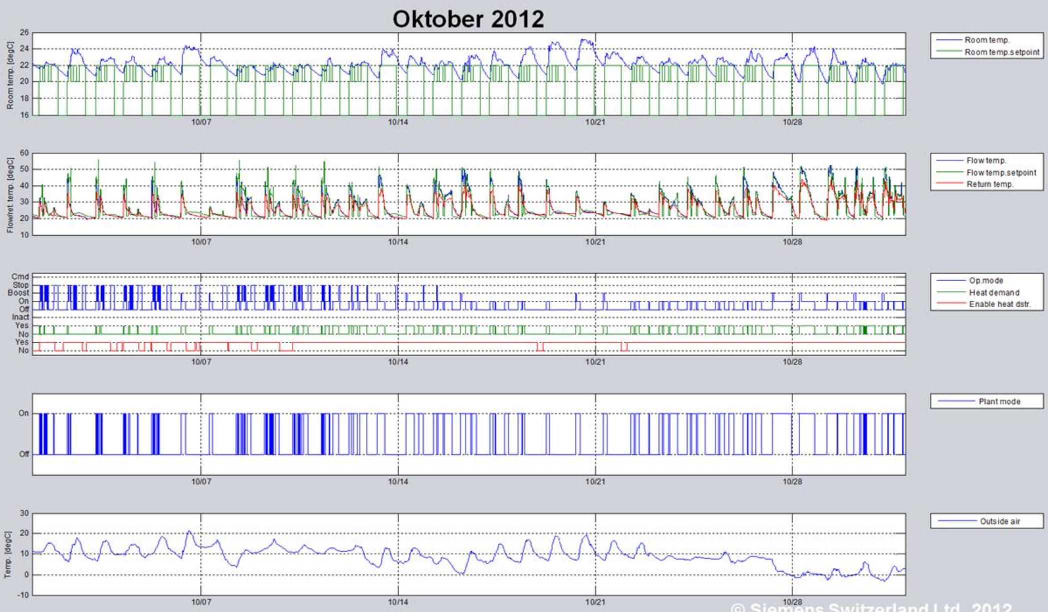
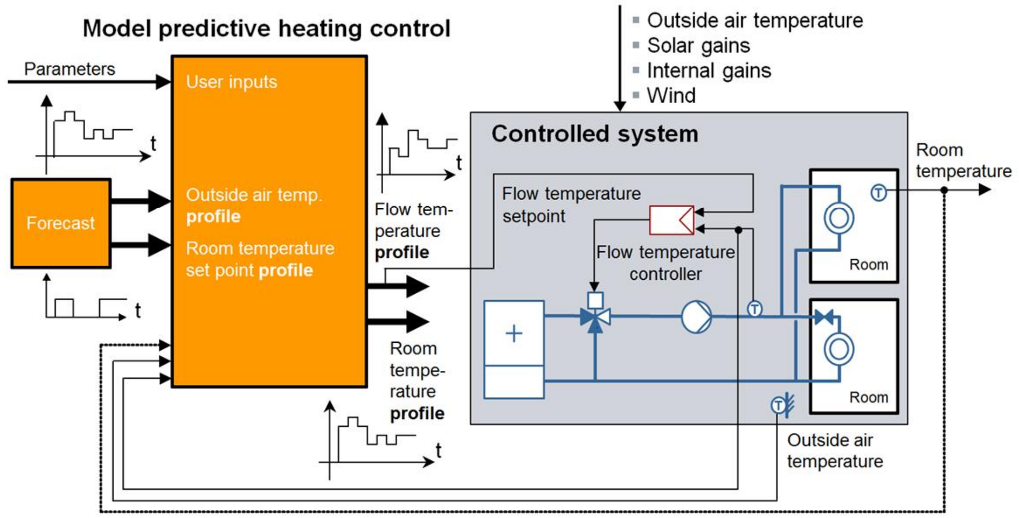



Demo

Predictive heating control
Demo




Questions and
discussion

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AirOptiControl

Demand-optimized air volume flow with optimum pressure distribution

DESIGO – Energy efficiency applications

RC-SE, December 2012

Author: **Benedikt Schumacher, 3043**

Revision: 1, 19-Nov-2012
Document status: Approved – valid without signature

Infrastructure & Cities / BT

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Revision history

Rev	Date	Author	Changes, Comments dh1
1	19-Nov-2012	Benedikt Schumacher	Status=Final - without Approval

Bild 2

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dh1 How to remove or insert table rows?
- right mouse click
- Delete Rows
- Insert Rows (befor the selected row)

Use Toolbox > Template Setup to update a template and the revision history for the template.
Donat Hutter; 2008-02-29

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Introduction/content

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- Development history
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- Benchmarking
- Use
- Delivery scope
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Background information: Parameter optimization with Frauenhofer, simulation infrastructure

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Development history

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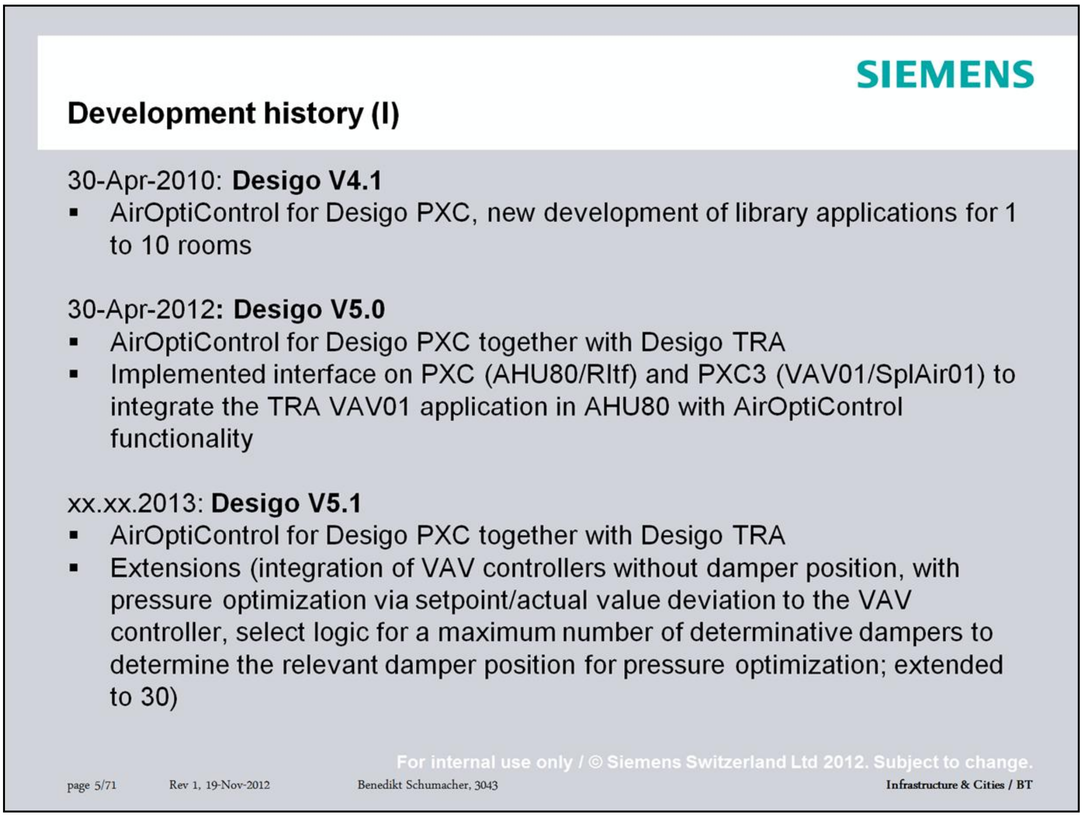
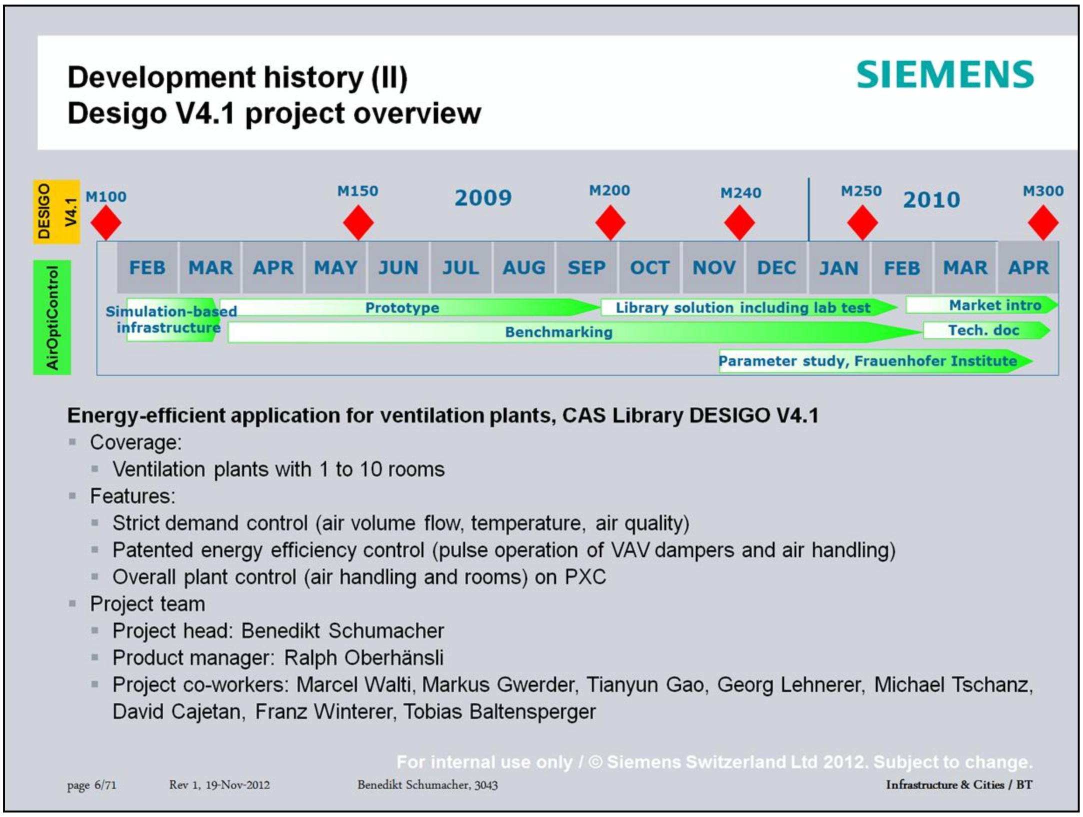


OEM-VAV controller: 0..10V signals for volume flow setpoint and damper position as a supplement to the PL link devices (0.100%)



After a rather difficult start – a thesis did not make a significant impact – an actual project was set up at the start of 2009 that was transferred shortly thereafter to a partial project as part of V4.1; this permitted access to important resources.

Resources

Schedule (actual)

What started out as a narrow project concept with a short implementation period, eventually turned into a veritable project. As time passed, requirements were established for comprehensive benchmarking in the A/C lab, a field test, and a study together with Frauenhofer

What did we get for the considerable investment?

DESIGO library solutions (4 new plant compounds)

Visualization using DESIGO INSIGHT

Technical document

- Reference manual
- Expert guide

Sales documentation

Demonstration application

Technical doc -> Ref-HB elements explained for AHU80, then the coordination for RDmdCtl2 and switch to RDmdCtl1 and explanation of EEffCtl and EEffOpt

Technical doc -> Display content of Expert Guide, Application table pg.123, Efficiency control pg.188

Sales documenation -> Display content, especially the numbers

Demostration application -> Start demo (explain elements, conventional, explain AirOptiCtl, simulation)

Conclude with Genie

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Function

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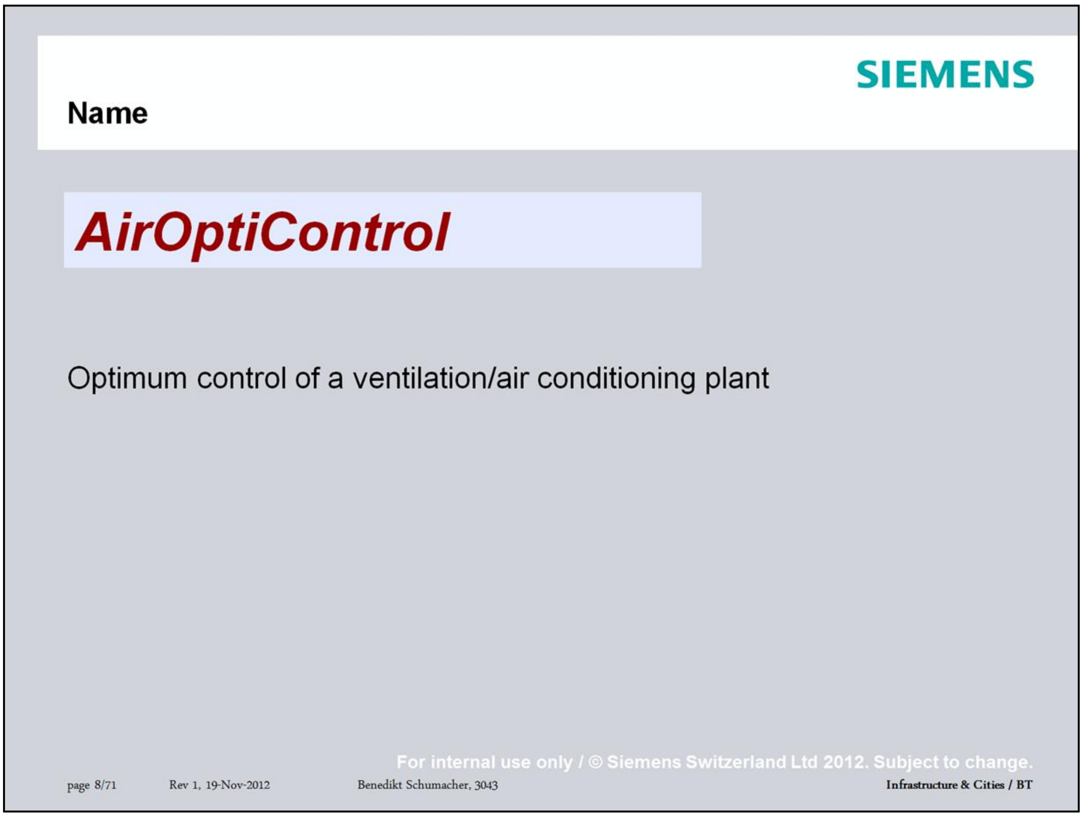

Nothing more, nothing less:

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System, goals, solution

Considered ventilation/air conditioning plant system

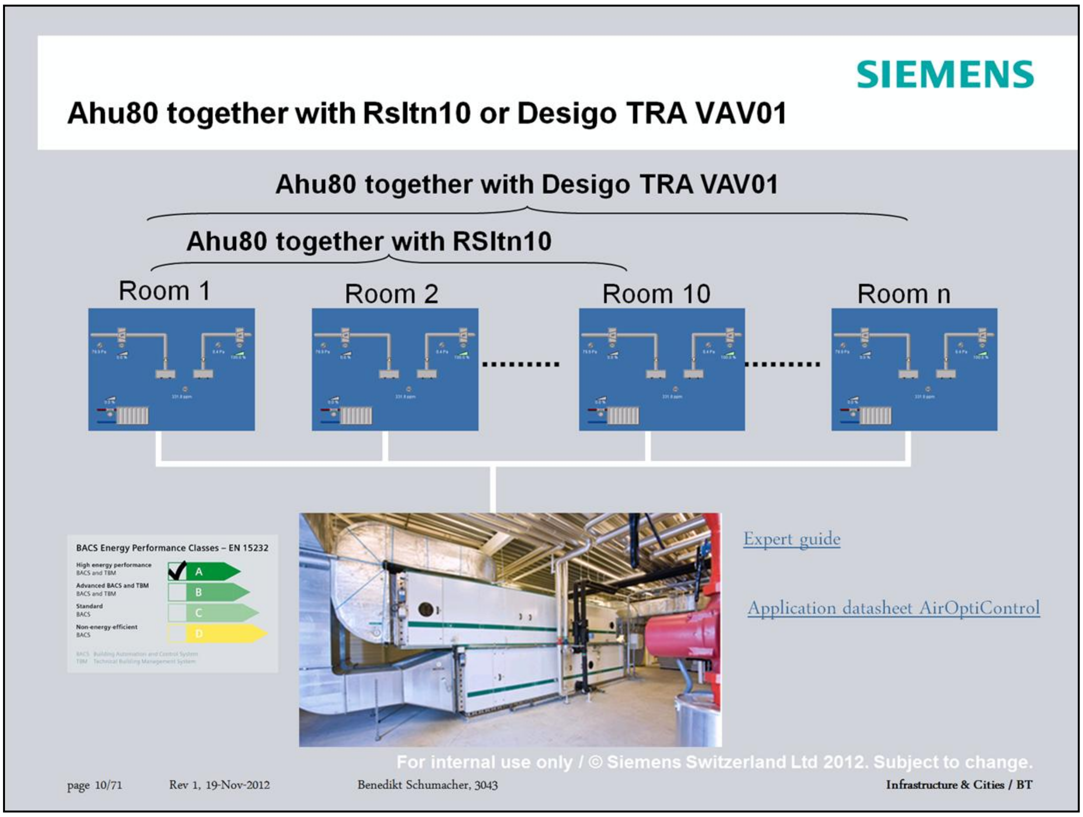
- Rooms
- Air ducts, VAV box, air outlet, air handling unit (fans, mixing air dampers, heating coils, cooling coils, energy recovery, humidifier, etc.)

Goal:

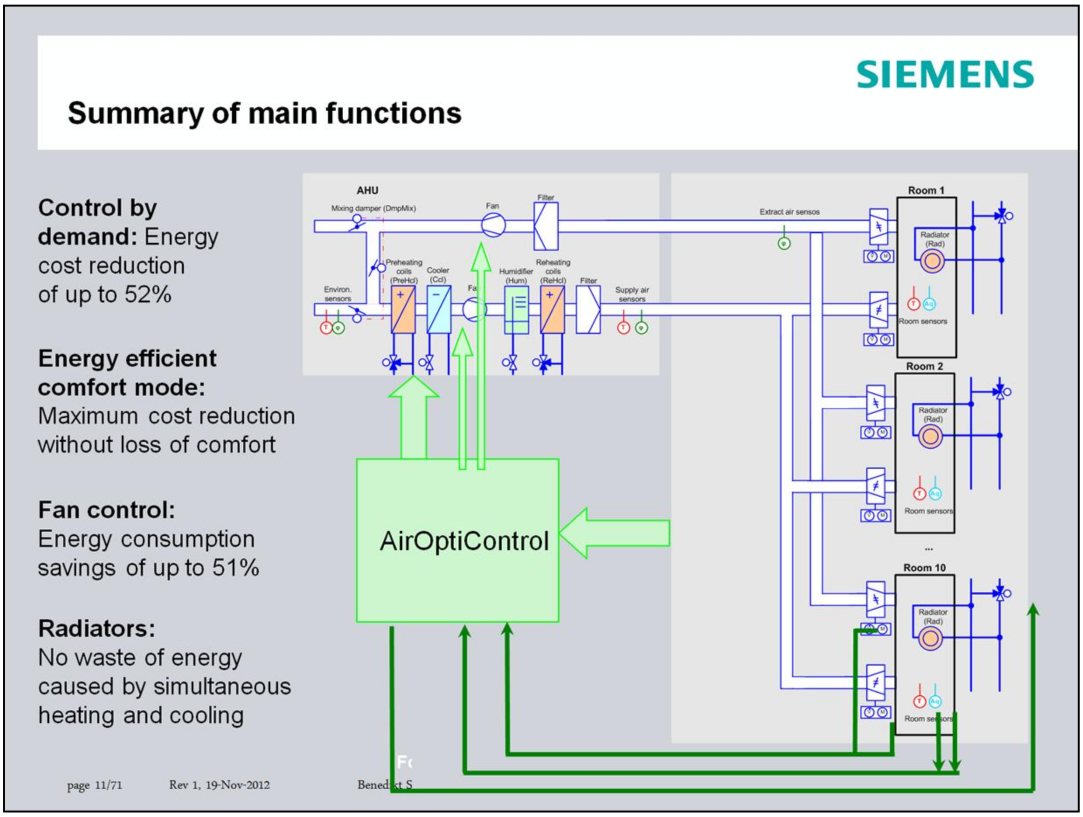
- Energy savings on air transport (fan energy)
- Energy savings on thermal air handling (heating, cooling, humidification, dehumidification)
- Ensure comfort

Solution "AirOptiControl":

- Demand-controlled control strategy (temperature, humidity, air quality)
- Energy-efficiency control (intermittent operation, or "pulse mode")



In the expert guide, show: Visio AHU80/RSltn and AHU/SplyAir01/VAV01



Modular, partial optimization is possible. Start, for example, with fan optimization

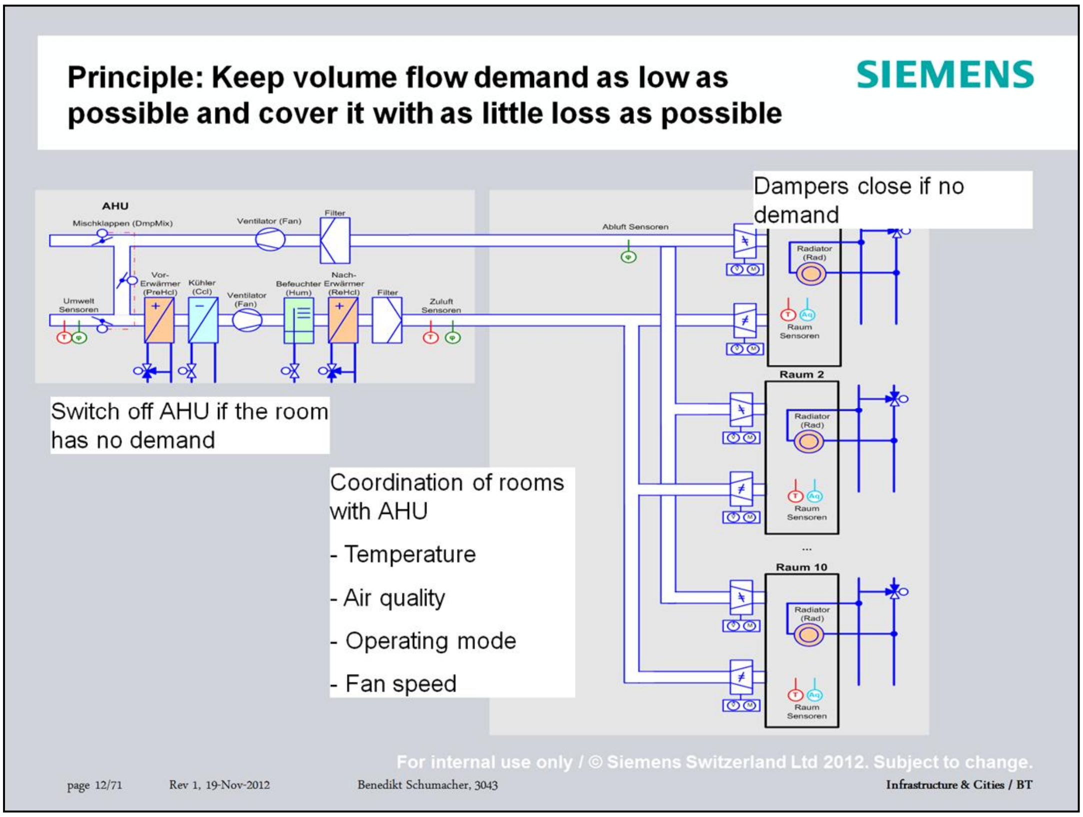
Modular units:

Pressure optimization (pressure coordination) -> Lower fan energy consumption

Temperature optimization -> centralized optimization of the temperature level helps reduce air volume flow demand at air quality optimization

Energy-efficiency control -> Switching off rooms or plants, as applicable, reduces air volume flow demand

Additional optimization: Radiator coordination, night cooling



Considered from another viewpoint:

Volume flow demand

a) Keep as low as possible

b) Cover demand with as little loss as possible

Lower volume flow also includes less thermal conditioning and less transportation energy.

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State, outlook

- AirOptiControl pursues nothing less than optimum ventilation and air conditioning control.
- Optimization factors include energy consumption, comfort, control accuracy (wear and tear of plant components).
- We come close to achieving this goal through consistent demand control with a goal of generating only the minimum volume flow to cover conditioning demand for the room, and to cover it was as little (pressure) loss as possible.
- Additional optimization measures such as coordinating water-based heating and cooling systems as well as night cooling, round out the package.
- Open is the integration of optimized control of energy recovery (Economizer tx2), control-technical measures for improving ventilation efficiency in the room (the unique nature of the ventilation type must already be considered today), energy costs or CO_2 emissions as primary optimization factors (the optimization factor “energy consumption” already covers these in large measure), etc.

Example for improving ventilation efficiency: System selection is presumably decisive, source ventilation must, however, be correctly operated from a control-technical viewpoint to take advantage of system advantages.

Sensor placement

…

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Benchmarking

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Benchmarking conducted on energy savings

Plant type	Control	Simulation	HVAC Laboratory	Field test (Steinhausen)	HWIL Simulation	Fraunhofer
H, C, Hmd, DeHmd	EEC 1R	**X (Nov09)**	**X (Nov09, Jan10)**	-	O	-
H, C, Hmd, DeHmd	EEC 10R	**X (Dec09)**	**X (Jan10)**	**X (Feb10)**	O	**X (Parameter for Vol-Opt.)**
H, C, Hmd, DeHmd	HQ 1R	**X (Nov09)**	**X (Dec09, Jan10)**	-	O	-
H, C, Hmd, DeHmd	HQ 10R	**X (Dec09)**	**X (Jan10)**	**X (Feb10)**	O	-
H (H,C)	RC-1 1R	**X (Feb09)**	O	-	O	-
H (H, C)	RC-1 10R	**X (March09)**	O	-	O	-
H, C, Hmd, DeHmd	Ideal Control 1R	O	-	-	-	-
H, C, Hmd, DeHmd	Ideal Control 10R	O	-	-	-	-
H, C, Hmd, DeHmd	SIA 1R	X (check/adapt room demand)	-	-	-	-
H, C, Hmd, DeHmd	Competitor 1R	O	**X (Feb10)**	O	O	-
H, C, Hmd, DeHmd	Competitor 10R	O	**X (Feb10)**	O	O	-

X: done, O: Option (required for HWIL COM-SS), -: either not relevant or not possible

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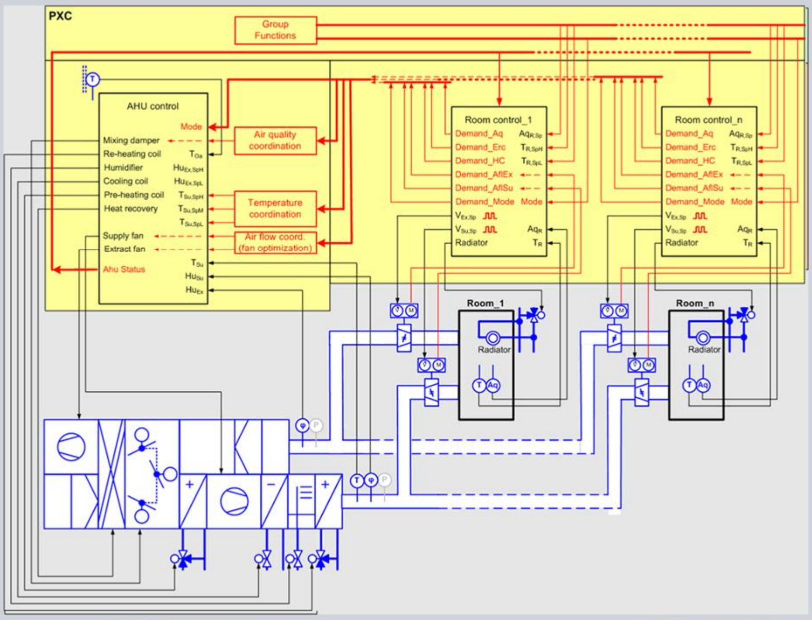
Benchmark application <-> AirOptiControl

Features
- Energy efficiency control (intermittent operation) of VAV
- Coordination between rooms and air handling
  - Operating type
  - Volume flow
  - Temperature
  - Air quality

Features (Workflow)
- Room applications and grouping function on PX as well
- Signal bundling via BACnet



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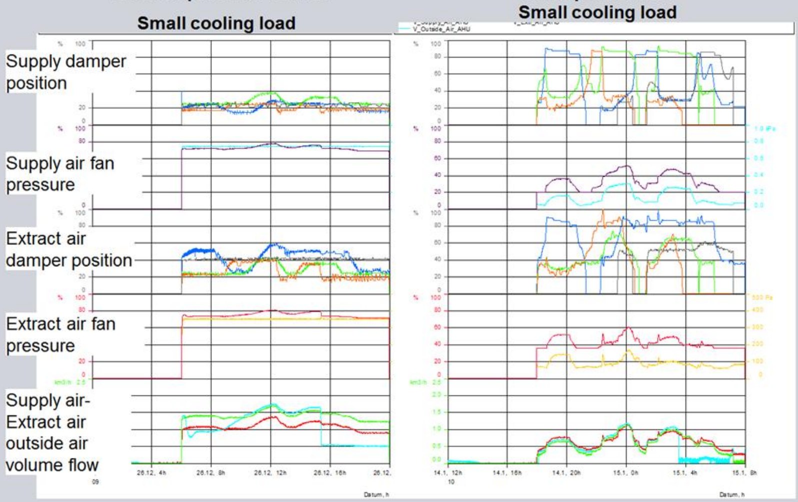
Benchmarking in HVAC lab

Energy savings

- Savings an fan energy of up to 70%
- Savings on cooling energy of up to 30%

Benchmark application:
Constant pressure control
Small cooling load

Air-Opti-Control:
Fan optimization
Small cooling load



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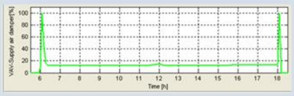
Benchmarking using simulation

Coordination between room and air handling

VAV dampers

Benchmark (constant pressure control)

- Temperature and AQ control
- Vmin 20%



AirOptiControl (fan optimization)

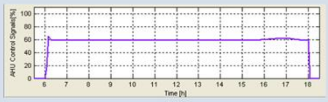
- Temperature and AQ control
- Without demand, dampers are closed (Vmin = 0%)
- At least one damper is maintained at max. open (80-90%)

➔Less pressure loss via VAV damper

Fan

Benchmark (constant pressure control)

- Constant air pressure



AirOptiControl (fan optimization)

- Demand-controlled fan to up temporary shut down based on the room demand signals operating mode, volume flow, temperature, and humidity

➔Supplies exactl s!

Mixing air dampers

Benchmark (constant pressure control)

- Constant outside air ratio (min)

AirOptiControl (fan optimization)

- Demand-controlled outside air ratio (down to 0%)

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Benchmark results (I)

Building: Typical training institution in Switzerland with 10 rooms
Primary plant: Heating: Natural gas burner, centralized air handling unit with heating coils
Cooling: Refrigeration machine, centralized ventilation plant with cooling coils
Room: Measurement: Temperature and air quality
Air system: Supply and extract air VAV

	Benchmark	AirOptiControl Functionality (AOC 1)	AirOptiControl Functionality (AOC 2)	AirOptiControl Functionality (AOC 3)	AirOptiControl Functionality 4 (AOC 4)
Control air volume	Constant air pressure	Based on demand	Based on demand	Based on demand	Based on demand
Energy Efficiency Control Mode	No	No	Yes	Yes	Yes
Control air quality	Constant outside air volume	Constant outside air volume	Constant outside air volume	Based on demand	Based on demand
Control temperature	Supply air temperature adjusted by outside temperature	Supply air temperature adjusted by outside temperature	Supply air temperature adjusted by outside temperature	Based on demand	Based on demand
Night cooling	No	No	No	No	Yes

Comment: The test series are based on real measurements, confirmed by simulations.

Please attention to the details.

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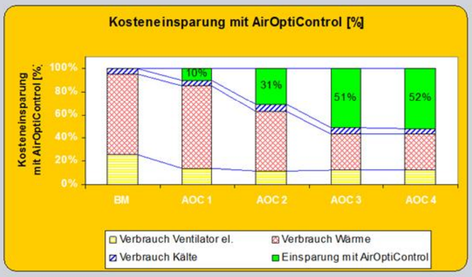
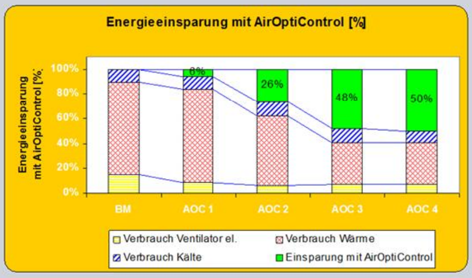
Benchmark results (I)

Depiction after cost savings [%]



Depiction after energy savings [%]



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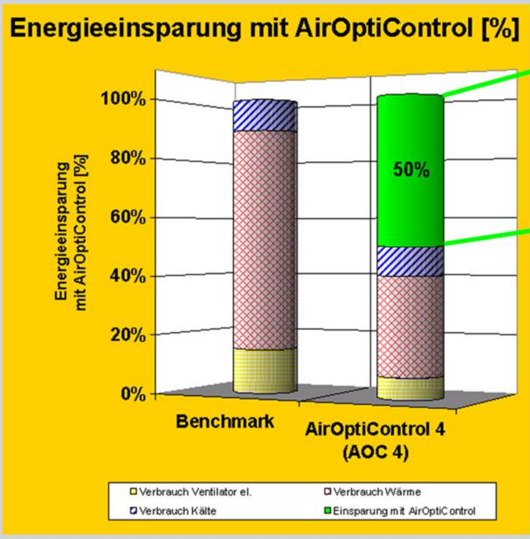
Benchmark results (I)



Energy savings relating to the benchmark

Elec. power for fan	**51%**
Heat	**55%**
Refrigeration	**6%**

- Electrical fan energy is cut in half using AirOptiControl.
- Fossil fuels such as oil, coal, and natural gas are often converted to electricity, so that AirOptiControl become and excellent means of reducing CO_2 emissions.

Application datasheet AirOptiControl

Comment: The test series are based on real measurements and confirmed by simulations.

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Use

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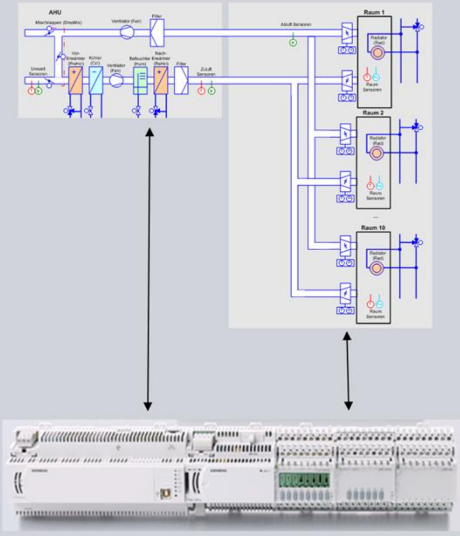
System hardware

The AirOptiControl application exists as a complete solution for the product range PXC100/200 and TX-IOs for one primary plant and 1 to 10 rooms.

As of Desigo V5.0, the rooms can be controlled as an alternative with PXC3 and coupled to the primary plant on PXC.



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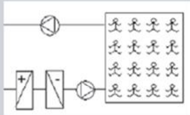
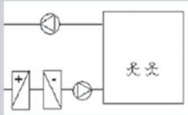
Applications

In general, rooms with:

- Variable occupancy / partial loads
- Own ventilation or air conditioning plant

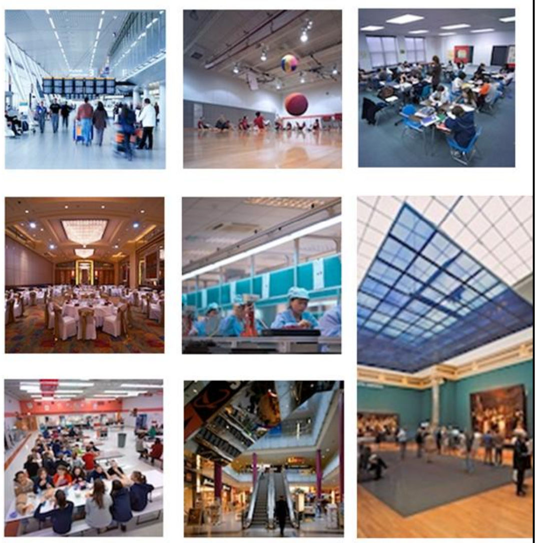




Suitable for both new business as well as migration business

Application datasheet

AirOptiControl



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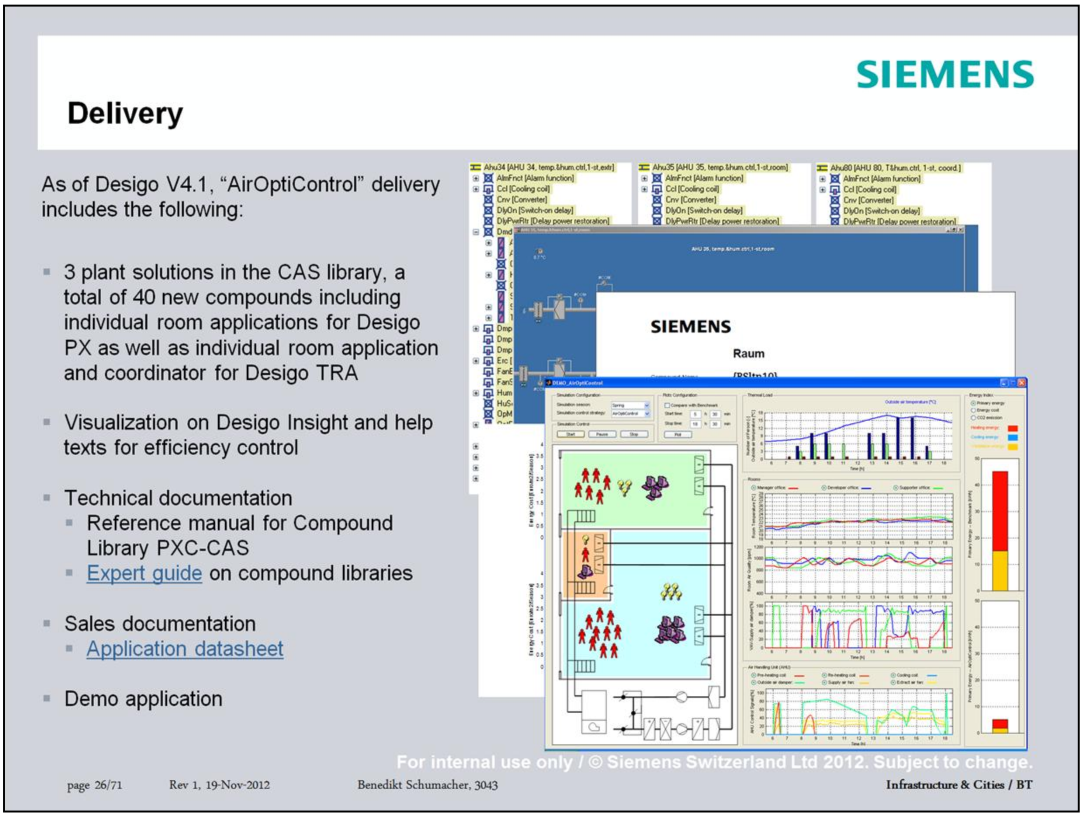

Technical documentation -> Explain ref-HB elements for AHU80 (A / APlt / Ahu), then explain coordination for RDmdCtl2 (A / AFnct / DmdAFnct) and switch to RDmdCtl1 and explain EEffCtl and EEffOpt

Technical doc -> Display content of Expert Guide, Application table pg.123, Efficiency control pg.188

Sales documentation -> Display content, especially the numbers

Demonstration application -> Start demo (explain elements, conventional, explain AirOptiCtl, simulation)

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Overview of plant solutions

From the expert guide: CM110748en.pdf

Plant	Number of rooms	Air quality control	Energy efficiency control	Energy efficiency optimization
{Ahu34} Air handling, temperature and humidity control, AQ control, 1-stage/VSD, Room variables measures in the extract air (see Section 8)	1	Yes	No	No
{Ahu35} Air handling, temperature and humidity control, AQ control, 1-stage/VSD, room variables measured in the room (see Section 8)	1	Yes	Yes Switch off the plant	Yes Increased supply air temperature and increased outside air ratio depending on the situation during operation for plant runtime optimization
{Ahu80}-> Air handling, temperature and humidity control, AQ control, VSD	Up to 10 rooms, -> suitable for {RGrp10}	Yes	Yes Switch off the plant	No
{RDmdCtl11} Coordination signals between {Ahu80} and TRA	Resolved in TRA via {SplyAir}	Yes	Yes Demand controlled from the rooms	No
{RGrp10} VAV room control with/without radiator heating for up to 10 rooms and grouping functions	Up to 10 room, -> suitable for {Ahu80} and {HGrp65}	Yes	Yes De-couple the rooms from the air handling unit (close VAV dampers)	No
{RSltn10} VAV room control with/without radiator heating	1 -> suitable for {RGrp10}, {Ahu80}	Yes	Yes De-couple rooms from the air handling plant (close the VAV dampers)	No

Desigo PX Library
new compounds as of Desigo V4.1

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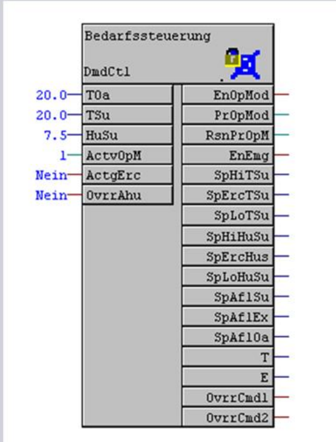
New compounds:

Coord.plant op mode-demand 1	CooPltM1*
Coordinator Temp demand 1,	Zuluft CooTDmd1*
Coord. air quality demand 1	CooAqDmd1*
Temp. cascade control 2, op mode	TCasCtl2
Hum. cascade control 1, rel.&abs.	HuCasCtl1
Air quality control 1,max.lim.	AQualCtl1*
Energy efficiency control 1	EefCtl1*
Ventilation control1, Setp. vol flow	VntCtl1
Extract air demand control 1	ExDmdCtl1*
Room demand control 1,	Eff reg. RDmdCtl1*
Room demand control 2, to 10 rooms	RDmdCtl2*
Energy efficiency optimizer 1	EefOpti1*
Fan optim.1, deviation	FanOpti1*
Fan optim.2, damper pos.	FanOpti2*
Room setpoint calculation 1	SpRCalc1
Air handling 34, T&H cont,1-st,extract	Ahu34*
Air handling 35, T&H cont, 1-st, room	Ahu35*



Desigo PX Library
new compounds as of Desigo V4.1

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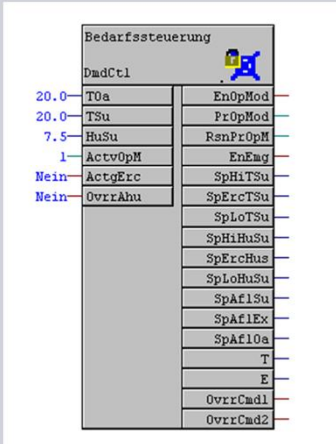
New compounds:

Air handling 80, T&H,cont, 1-st,coord	Ahu80*
Air handling 81, T&H,cont, 1-st,rooms	Ahu81*
VAV, internal controller 10	VavCtr10
VAV, external controller 10	VavExt10
Radiator, modulating control 10	RadMd10*
Room setpoints 1, H & C & AQ	RoomSp1
Fire op mode 1, smoke extract.	FireMod1
Scheduler 1, Opmode&NightC.	Sched1*
Plant op mode limiter	LmPltMod*
Provide room setpoint	PvdRSp
Provide summer/winter comp.	PvdSwCmp
Provide scheduler	PvdSched
Provide room demand	PvdRDmd
Provide room air demand	PvdAhuSta
Get room setpoint	GetRSp
Get summer/winter compensation	GetSwCmp
Get scheduler	GetSched



Desigo PX Library
New compounds as of Desigo V4.1

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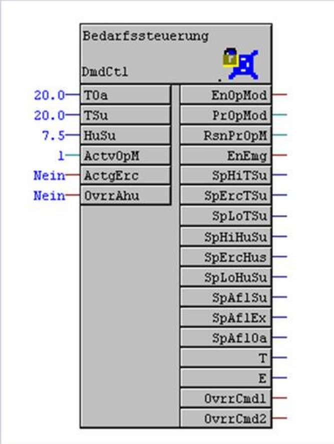
New compounds:

Get room demand	GetRDmd
Get air handling status	GetAhuSta
Room 10, supply&extract VAV,	Rad RSltn10*
Room group 10, up to 10 rooms	RGrp10*
Two-point control	TwoPtCtl
Setpoint for heating&cooling demand	SpHCDmd*



*Compounds that support energy efficiency

Desigo PX Library
New compounds as of Desigo V4.1

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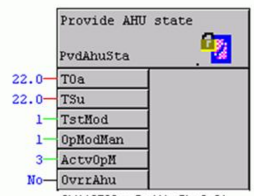
Compound to bundle and provide up to 15 real, integer, and Boolean values each using interconnection or a BACnet reference.

PvdAhuSta

The compound bundles signals for simplified transmission to individual rooms. It consists of a firmware block Multiplexer "MUX101" as well as an AVAL block. Input values are encoded by provided through the AVAL-OP block {PvdData}.

The number of required inputs per data type can be defined using parameters "NumInR" / "NumInMs" or "NumInB".
Input number always begins with "Inx1".
The number of inputs defined in {Pvd99} must match the defined outputs in compound {Get99} using recipient "DMUX 101".



CM110739en-PvdAhuSta-3_01

Link to reference manual LED15, s1277 (R / RFnct / GrpRFnct)

Desigo PX Library
New compounds as of Desigo V4.1

SIEMENS

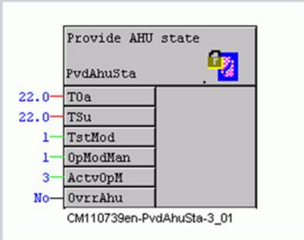
Input values are generally transmitted in sequence. If a change of value occurs at an input, the changed value is then transmitted with priority.
In order to recognize a change of value for Real values, the change of value must be greater than the parameters COV. "COV" can be defined separately for each input.

In the event a value is exceeded at the input, the value is limited to the maximum permissible value. The recipient block detects the violation and indicates it as an error.

To ensure compatibility of provide and get function blocks, versioning is added to the firmware blocks which checks this during runtime.

The compound is used in compounds for signal bundling:
– {PvdRSp} Provide room setpoint data
– {PvdSwCmp} Provide summer/winter compensation data
– {PvdSched} Provide scheduler data
– {PvdRDmd} Provide room demand data
– {PvdAhuSta} Provide air handling status data

PvdAhuSta



Desigo PX Library
new compounds as of Desigo V4.1

SIEMENS

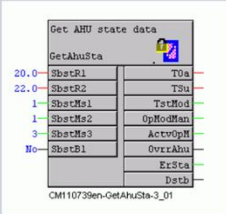
Compound to receive and unbundle up to 15 Real, integer, and Boolean values each using interconnection or BACnet reference.

GetAhuSta

The compound bundles signals provided to the room.
It consists of a firmware block Multiplexer "DMUX101" as well as an AI block.
The encoded values are retrieved with the AI block {GetData} and forwarded to the input for {Dmux}.

The number of required outputs per data type can be defined using parameters "NumOutR" / "NumOutMs" or "NumOutB".

Output numbering always begins with "Outx1".
Versions are added to the firmware blocks to ensure compatibility between the provide and get function blocks; they can be checked during runtime.
In the event of an error, the value 2 for “Version error” is outputted at output [O7: ErSta].



Desigo PX Library
New compounds as of Desigo V4.1

SIEMENS

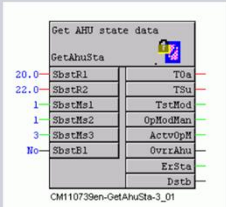
To ensure that the same number of values per data type are actually set on Multiplexer and Demultiplexer, a checksum is formed and evaluated.
If the checksum is incorrect, the value defined in parameters "SbstXx" is written to the outputs and outputted at output [O7: ErSta] of value 3 for checksum error.

Transmission is monitored. It checks whether the received value is constantly changing (recognition), or whether input 'Rlb' for {Dmux} is not equal to "0".
In this case, the values defined in the parameters "SbstXx" are written to the outputs and outputted at output [O7: ErSta] of value 4 for „Communications fault“.

In the event of an value violation at the input, the value is limited to the maximum permissible value. The violation is detected by the recipient bloc and output at output [O7: ErSta] for value 5 for “Value outside the range".
The value 6 for “Initialization” is outputed at output [O7: ErSta] of value 6 when starting up the automation station until all values are received.

The compound is used in compounds for signal bundling:
− {GetRSp} Get room setpoint data
− {GetSwCmp} Get summer/winter compensation data
− {GetSched} Get scheduler data
− {GetRDmd} Get room demand data
− {GetAhuSta} Get air handling status data

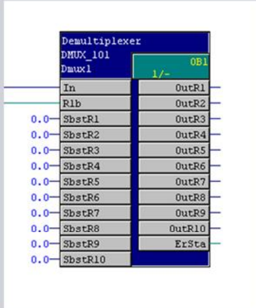
GetAhuSta

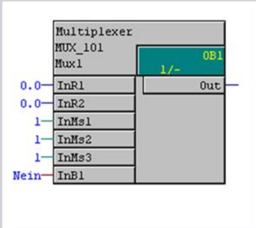


CM110739en-GetAhuSta-3_01

Desigo PX Library
New blocks as of Desigo V4.1

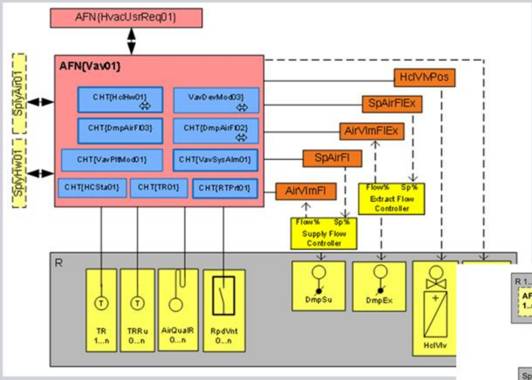
FB969 / FB965 do not exist in the firmware library



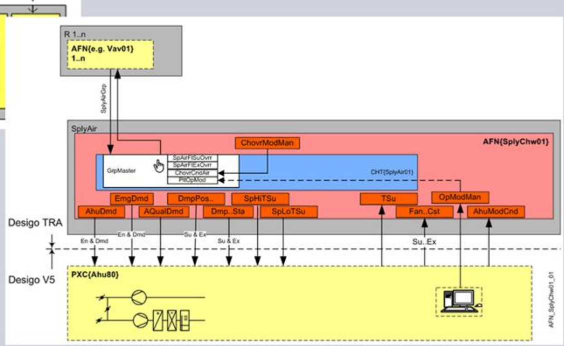


Desigo TRA Library
New application functions as of Desigo V5.0

SIEMENS



AFN VAV01



AFN SplyAir01

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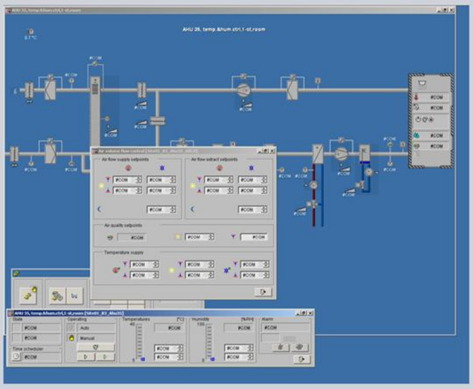
Desigo Insight Library



Help texts to energy efficiency control and energy efficiency optimization:

- CM110746en-EefAhuOp.pdf
- CM110746en-EefOptiAhuOp.pdf
- CM110746en-EefROp.pdf

For help texts, see:

\\ch1w43110.ww020.siemens.net\Desigo_Distr\V4.10.090_M300\044_TechDoc_ExpLevel_DVD\ContentLists\de\2004_insight.htm

Explain energy efficiency optimization

SIEMENS

Documentation

Solutions-related documents (.pdf-Format):

- Energy efficient applications: AirOptiControl - Application datasheet (product datasheet) CM110745en.pdf
- Compound libraries LED16, Expert guide (construction - project planning) CM110748en.pdf
- Engineering sequence controls (construction - project planning) CM110427en.doc
- Engineering plant controls (construction - project planning) CM110428en.doc
- Compound libraries, reference manual LED16; Reference to source data (construction - project planning) CM110711en-LED16.pdf
- Library of blocks Online help, XWP (construction - project planning) CM111011en.zip

Solutation-related sources (.doc-Format):

- \\CH1W43110\Desigo_Distr\V4.10.090_M300\018_Sources_for_LED16_CD\01_Documentation\CM110745_Application_datasheet_AirOptiControl
- …

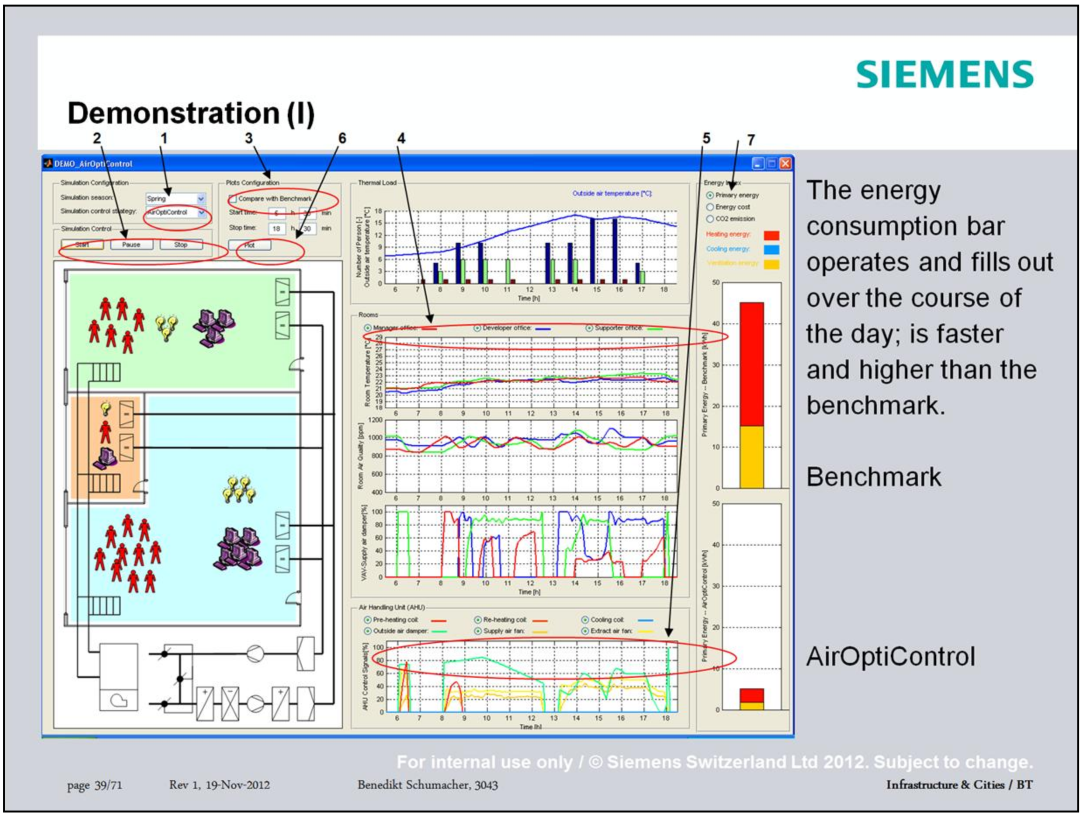
Overview documents on energy efficient applications (.pdf-Format):

- Energy efficiency in building automation and control
  Application manual ventilation and air conditioning
- Energy efficiency in building automation and control
  Application manual heating and refrigeration supply
- Desigo
  Tested applications – sustainable energy efficiency
  Order number: 0-92232en

Introduction on the topic of "Energy efficiency"

- www.siemens.com/energyefficiency

Link in document: Reference manual, expert guide, application datasheet



Online comparison (Demo 3):

Preparation:

1) Start Matlab: Start -> Programs -> Matlab -> R2006a -> Matlab R2006a

2) Open demo: Under "Current directory" on the Matlab menu bar, create the work folder: C:\Data\Demo

3) Start demo: In the "Current directory" pane, right-click file DEMO_AirOptiControl.m and click **Run**
Alternative method: In the "Command window" pane, enter "DEMO_AirOptiControl" at the prompt and confirm with **Enter**

Operating elements:

1 Configuration: Select benchmark or AirOptiControl. Both control strategies can be displayed individually or simultaneously.
Caution: Both strategies can only be displayed in the "AirOptiControl" mode by selecting checkbox "Compare with Benchmark". This checkbox can be selected or cleared during or at the end of simulation

2 Start, Pause, Stop: You can pause and continue simulation be re-clicking pause

3 Checkbox "Compare with Benchmark": This check can be selected during or at the end of a simulation and compares results of both strategies in the "AirOptiControl" mode

4 Room data selection: The variables displayed, depends on selection. You can displayed just one room online by clearing the remaining rooms

5 Plant data selection: Same as 4

6 You can use plot to display a comparison curve at the end of simulation by selecting "Compare benchmark", if the simulation occurred using the "AirOptiControl" mode

Graphs:

1 Last, internal (people, light, devices) and external (outside air temperature)

2 Room temperature (heating setpoint = 21°C, cooling = 26°C)

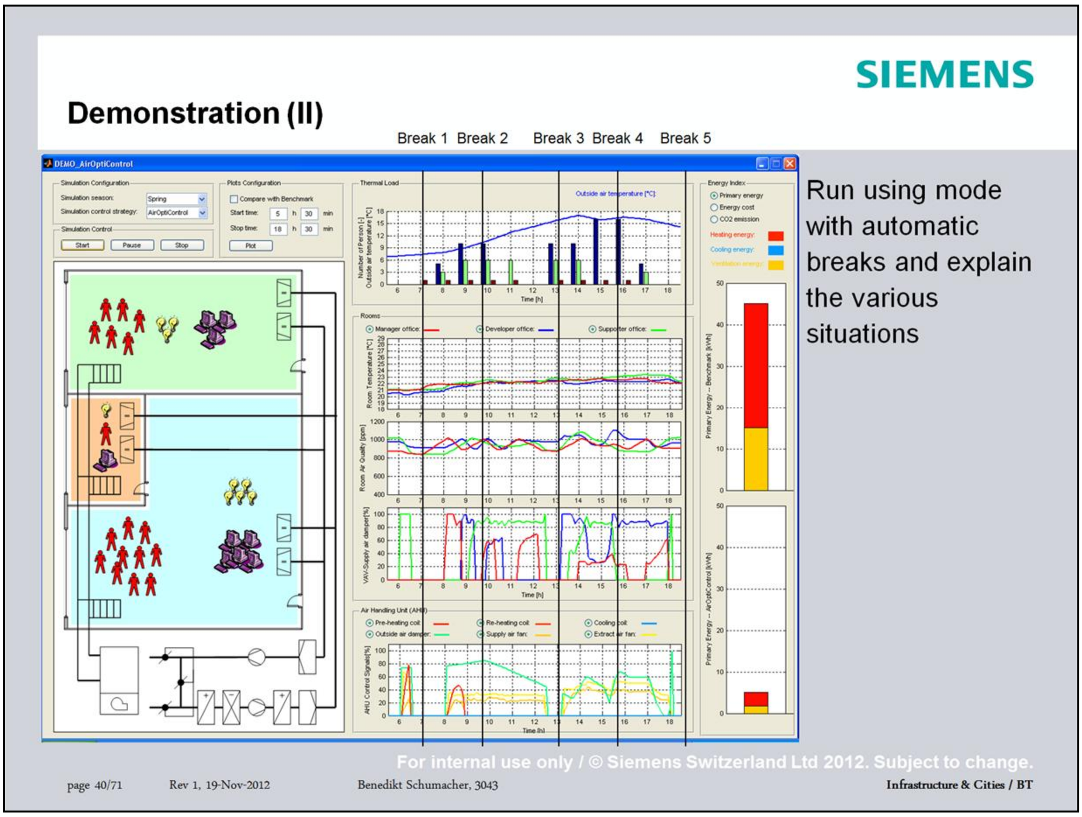
3 Room air quality (setpoints occupied/comfort = 1000ppm)

4 VAV damper position (non-linear, i.e. 20% damper position equates to 50% volume flow)

5 Control of supply air fan, heating coils, cooling coils

Tip:

If little time is available, run the demonstration in the "AirOptiControl" mode and explain why the energy bars increase at various speeds. You can show/hide the benchmark comparison at any time in this mode



A break is planned at item 7:

Break 1 (shortly after 8:00): Plant start until room occupancy

Start procedure: Dampers open, fan on, room control activated

Conventional: Plant operates independent of room demand, dampers deploy to minimum position, since there little/no demand in the room for ventilation and air conditioning due to partial load in spring.

AirOptiControl: Plant operates for a brief moment, until the air quality setpoint is reached in the green room. The plant remained switched off on its own in the occupied red room. It only restarts after the air quality setpoint is exceeded in the red room.

Break 2 (10:00): Effect of volume flow coordination

Conventional: Air quality in all rooms is ok. The room is nevertheless ventilated and the supply air must be heated due to the cool morning outside air temperature.

AirOptiControl: Volume flow coordination: The supply air fan is controlled in the function of the VAV damper positions so that at least one VAV damper is open -> Impact on fan control: Less output required since less pressure is destroyed. Nice to see how first the red, then the blue, and finally the green room assumes fan control. A slight “boost” is enough to ensure air quality in the rooms. Slightly before 10:00, all the room require fresh air at the same time. The green room remains the lead variable for fan control.

Break 3 (11:00): Individual rooms without temperature and air quality demand switch off

Conventional: No shut down.

AirOptiControl: Red room switches off shortly before 9:00 and 10:30 although occupied. The blue room switches off at 9:30 and 10:30 despite occupancy.

Break 4 (12:30): The entire plant switches off, since the room has no demand

Conventional: No switch off.

AirOptiControl: 12:30 to 13:00 the entire plant switches off, since no room has demand

Break 5 (5:00 pm): People from the green room go to the blue office

Conventional: No switch off.

AirOptiControl: At 3:00 pm, the AQ deteriorates in the blue room which now assumes control. The two other rooms switch off.

Break 6 (not implemented in this demonstration -> explain only):

Conventional: Supply air temperature is controlled dependent on room demand.

AirOptiControl: Temperature coordination: The supply air temperature is controlled in the function room temperature so that for temperature demand, the supply air temperature is first increased before being forced to increase the volume flow in the to room to maintain temperature. This keeps volume flow demand in the room to a minimum.

Break 7 (no implemented in this demonstration -> Explanation only):

Conventional: Outside air ratio depends on room demand.

AirOptiControl: Air quality coordination: The outside air ratio is controlled in the function for room air quality and outside air temperature conditions to increase the outside air ratio for air quality demand. This keeps volume flow demand in the room at a minimum.

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Summary of delivery

- Modular library applications for Desigo PX and Desigo TRA, including Desigo Insight graphics library for plant operation
- Tool-supported variants for air handling unit control
- Tool-supported variants for fan optimization
- Individual room control/zone control for rooms or zones with VAV boxes and radiators
  Comment: Blinds and lighting control are not available on PXC due to insufficient response times of the PXC automation station
- Room-oriented grouping functions to distribute function values in multiple rooms, e.g. time switch commands
- Supply-oriented grouping functions to coordinate rooms using the air handling plant: Operating mode, volume flow demand, temperature demand, air quality demand
- Variants to demand control as per possibilities of various VAV box types, e.g. mapped, real, or no damper position (volume flow setpoint-actual value deviation)
- Trending available in air handling and room applications

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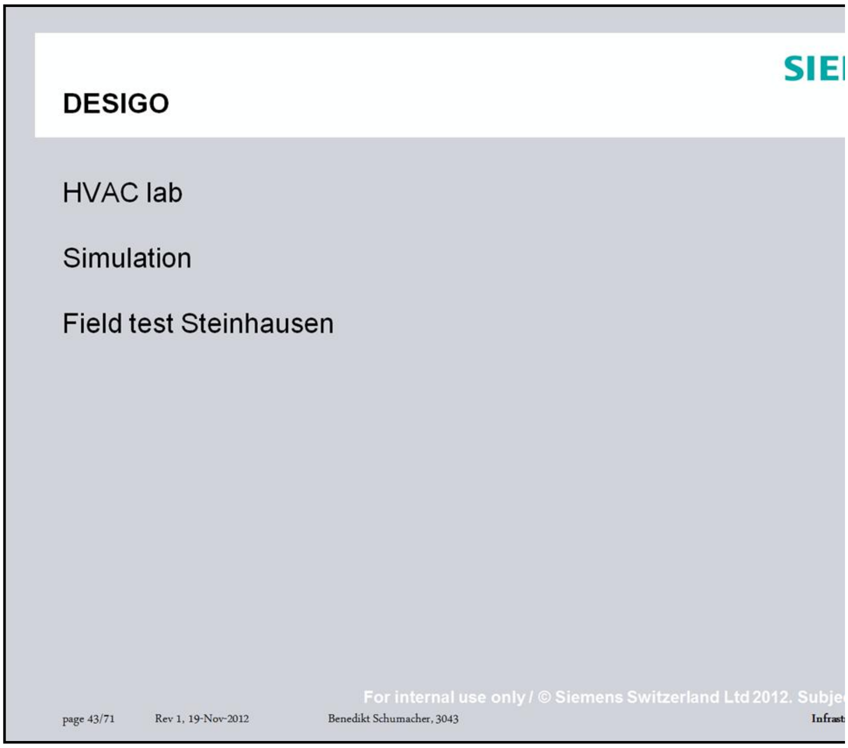
Experiences

Content

- Development history
- Function
- Benchmarking
- Use
- Delivery scope
    - Desigo PX Library
    - Desigo TRA Library
    - Desigo Insight Library
    - Documentation
    - Demo
- Experiences
- Advantages, customer benefits
- Background information



Schiffahrtsmuseum Husum, Schleswig Holstein.

Museumhalle mit konserviertem Lastensegler.

Die Energieeinsparung steht im Verhältnis zum erwarteten berechneten Energieverbrauch.

Enge Toleranzen und hoher Komfort gefordert.

Guter und sehr energie-effizienter Anlagenbetrieb.

Economiser tx2 in Verbindung mit CO2-Regelung.

Die Anlage regelt das Klima zur Konservierung eines alten Schiffes (Lastensegler). Das Schiff wurde in eine Zuckerlösung getaucht und muss nun getrocknet werden.

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Advantages, customer benefits

Content

- Development history
- Function
- Benchmarking
- Use
- Delivery scope
  - Desigo PX Library
  - Desigo TRA Library
  - Desigo Insight Library
  - Documentation
  - Demo
- Experiences
- Advantages, customer benefits
- Background information

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Advantages and customer benefits

Application datasheet
AirOptiControl

End customer

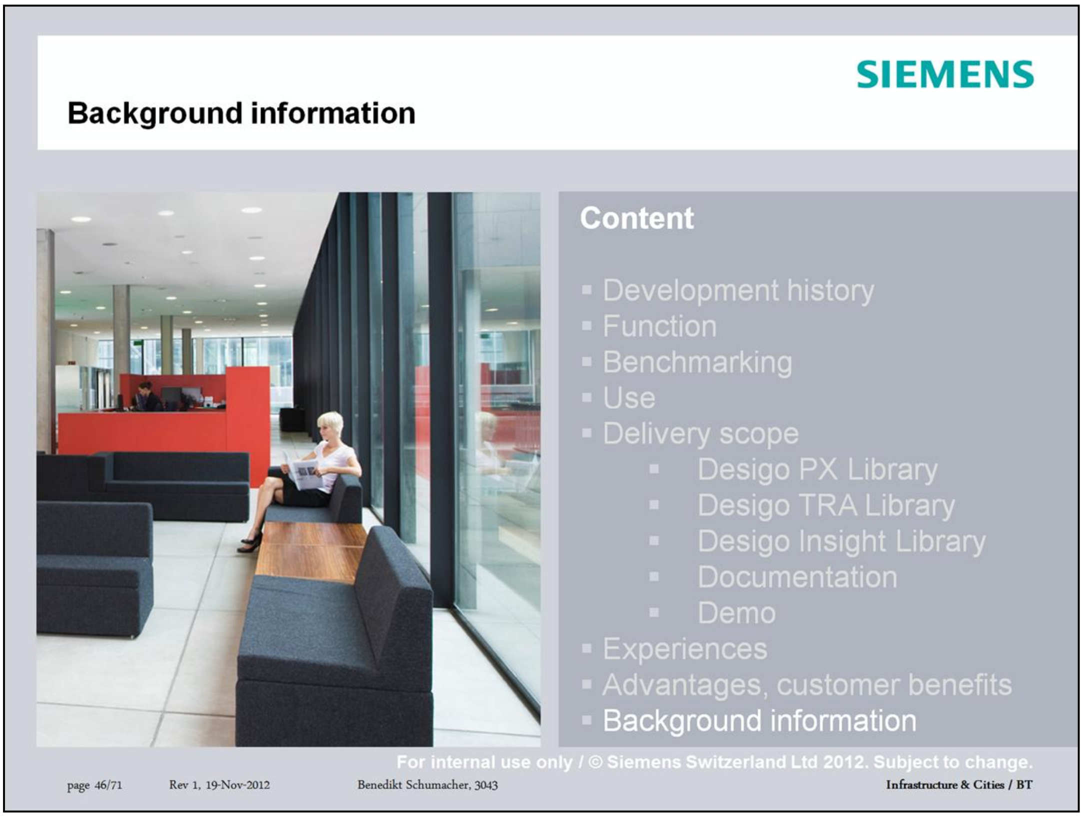
- Up to a 50% reduction in costs thanks to energy savings
- Lower maintenance costs thanks for energy savings of up to 50% versus a conventional demand-controlled VAV plant
- "Energy Efficiency Control" with potential for maximum energy savings while operating ventilation and air conditioning plants with one or up to 10, or "n" rooms
- Higher level of investment protection thanks to pan-European standardized energy efficiency class A

System house

- Understandable arguments based on benchmark results
- Modular, designed standard library applications including graphics for plant operation using DESIGO INSIGHT for easy engineering and commissioning
- Documented application to provide excellent service after Yeshren

Planners, architects, energy consultants

- Meets European standard EN 15232 in class A
- Permits ecological consulting and applications with lower emissions
- Convincing arguments for excellent advertising and customer relations
- Supports innovative building concepts



Hintergrundinformationen: Parameteroptimierung mit Fraunhofer, Simulationsinfrastruktur

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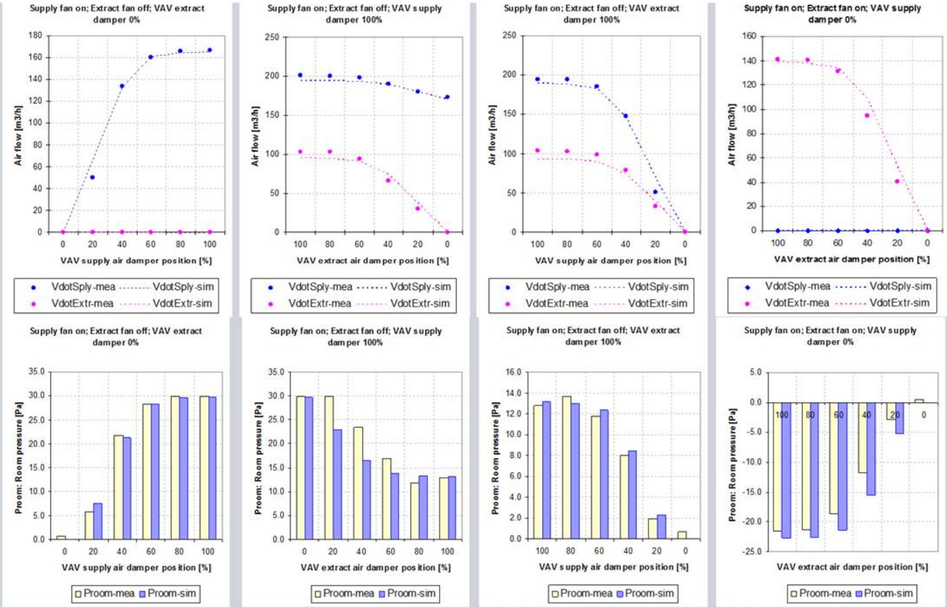
Simulation model validation



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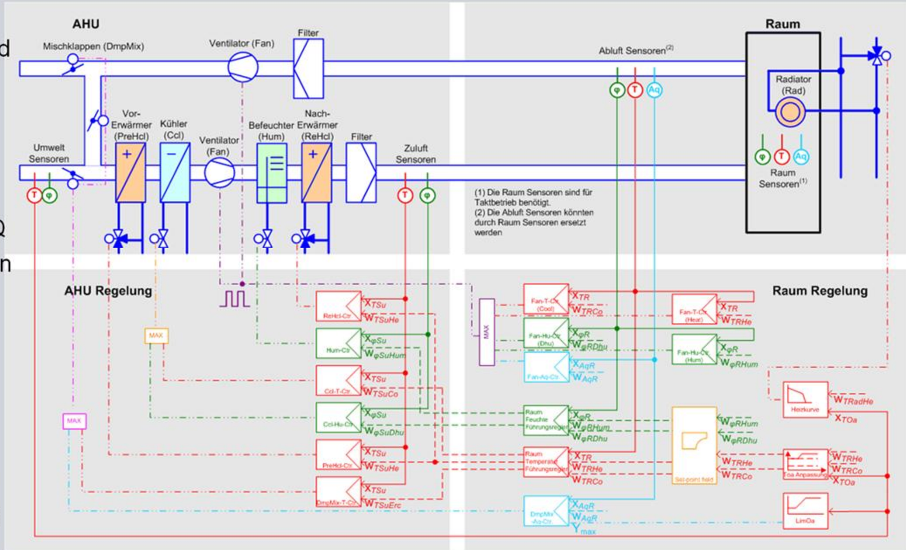
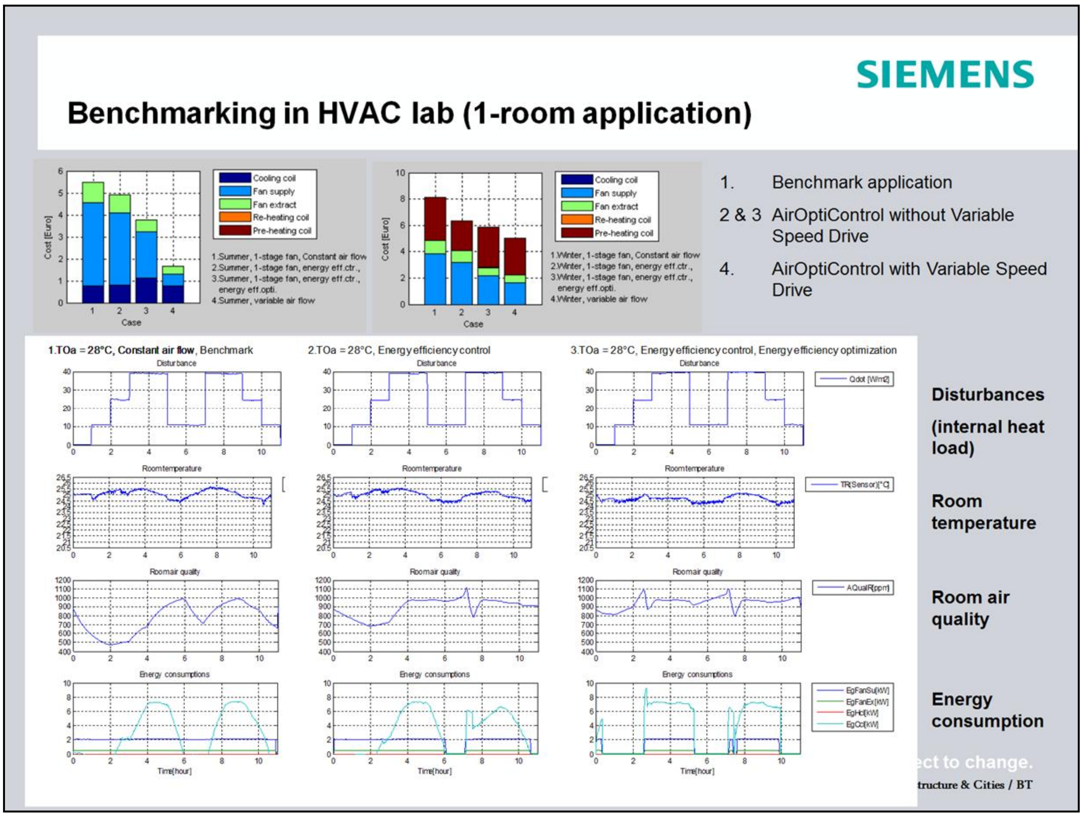
1-room benchmark application <-> Ahu35 (Ahu34)

Features

- AQ optimized mixing air damper control
- Temp., humidity, AQ controlled fan
- Energy efficiency control
- Energy efficiency optimization night cooing

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Benchmarking in HVAC lab (1-room application)
Cooling coil
Fan supply
Fan extract
Re-heating coil
Pre-heating coil
Cost [Euro]
Case
1.Summer, 1-stage fan, Constant air flow
2.Summer, 1-stage fan, energy eff.ctr.,
3.Summer, 1-stage fan, energy eff.ctr.,
energy eff.opti.
4.Summer, variable air flow
1.Winter, 1-stage fan, Constant air flow
2.Winter, 1-stage fan, energy eff.ctr.,
3.Winter, 1-stage fan, energy eff.ctr.,
energy eff.opti.
4.Winter, variable air flow
1. Benchmark application
2 & 3 AirOptiControl without Variable Speed Drive
4. AirOptiControl with Variable Speed Drive
1.TOa = 28°C, Constant air flow, Benchmark
2.TOa = 28°C, Energy efficiency control
3.TOa = 28°C, Energy efficiency control, Energy efficiency optimization
Disturbance
Roomtemperature
Roomair quality
Energy consumptions
Time[hour]
Disturbances
(internal heat load)
Room temperature
Room air quality
Energy consumption

Parameter optimization in cooperation wiht the Fraunhofer Institute, Germany

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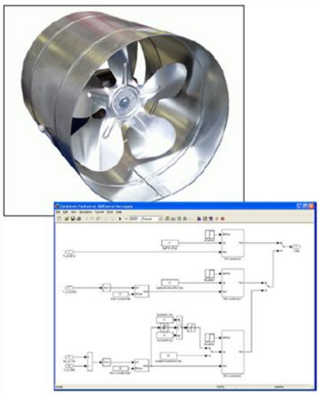


Optimale Bedarfsregelung von Ventilatoren

Zug, 23.10.2009

Bettina Berning
Thomas Sigl
Dr. Jens Wollenweber

Fraunhofer IIS

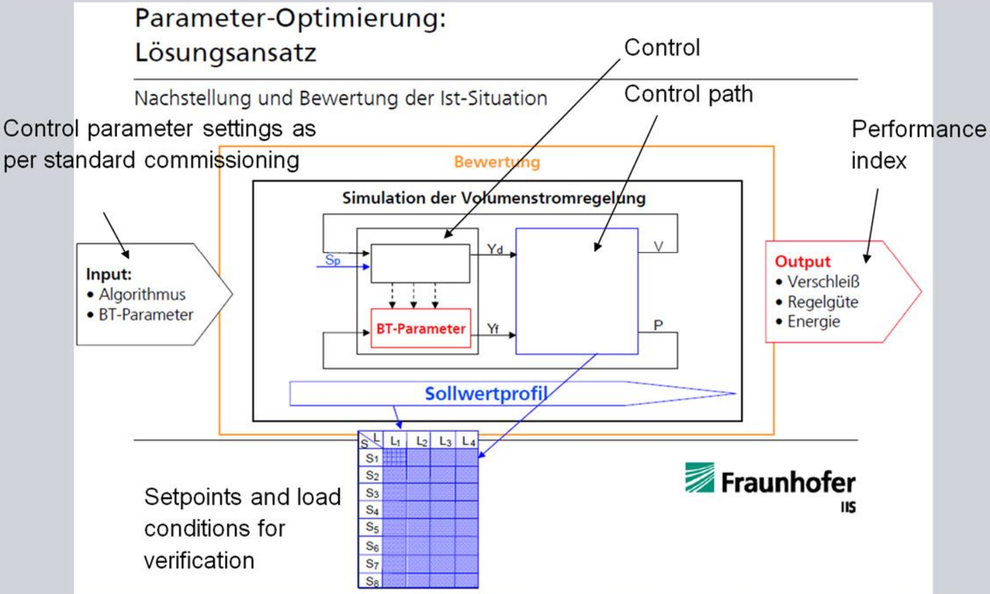
Task:

Finding optimum control parameter setting for various load situations and setpoint specifications

The performance index for assessing the optimum level for a weighted mix of "energy consumption", "control accuracy", and "plant wear and tear"

SIEMENS

Standard parameter settings



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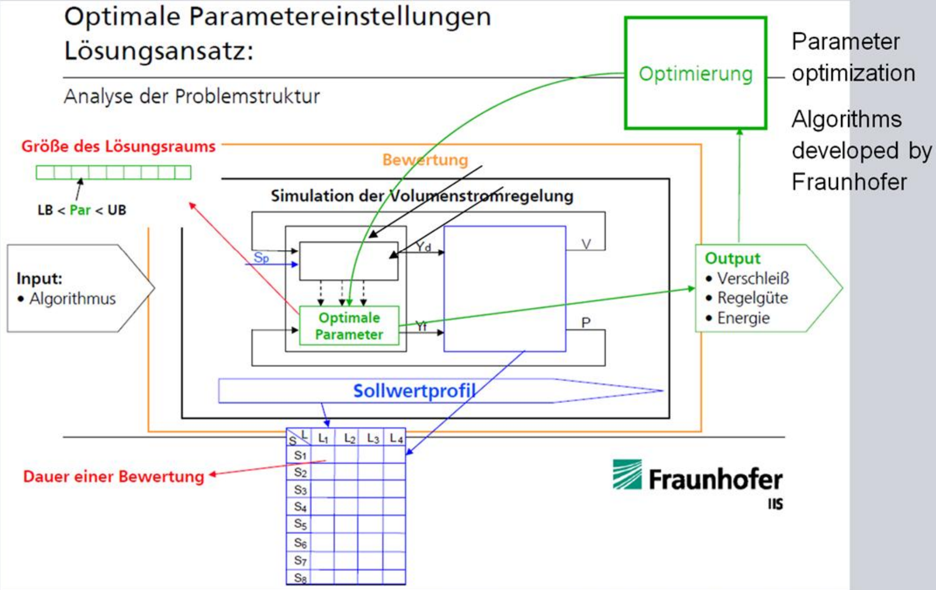
Optimized parameters settings



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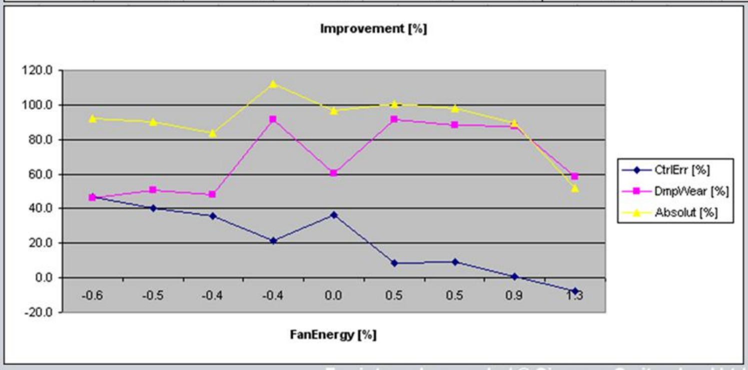
Results

	Control Parameter					Improvement [%]			
Set Nr.	SpMaxDmpP	Tcon	Gain	Tn	Nz	CtrlErr	FanEnergy	DmpWear	Absolut
Standard	90	2	0.5	300	0.0	0	0	0	0
1	86	2	0.3	42	2.7	46.9	-0.5	32.4	78.7
2	82	2	0.3	82	4.8	38.4	-0.5	36.9	74.9
3	86	4	0.3	82	2.7	35.0	-0.3	33.4	68.1
4	82	2	0.1	70	4	15.3	-0.4	43.0	57.8
5	86	2	0.3	82	2.7	34.9	0.0	39.9	74.8
6	89	2	0.2	134	2.3	2.0	0.5	45.6	48.1
7	88	1	0.2	134	2.3	2.9	0.5	44.2	47.6
8	88	2	0.2	134	2.3	-6.0	0.9	42.6	37.6
9	88	25	0.2	134	2.3	-12.8	1.3	-26.4	-37.9



Optimized, robust control parameters

SIEMENS

Press release

Fraunhofer
IIS

Presseinformation

Nürnberg,
12. Mai 2010

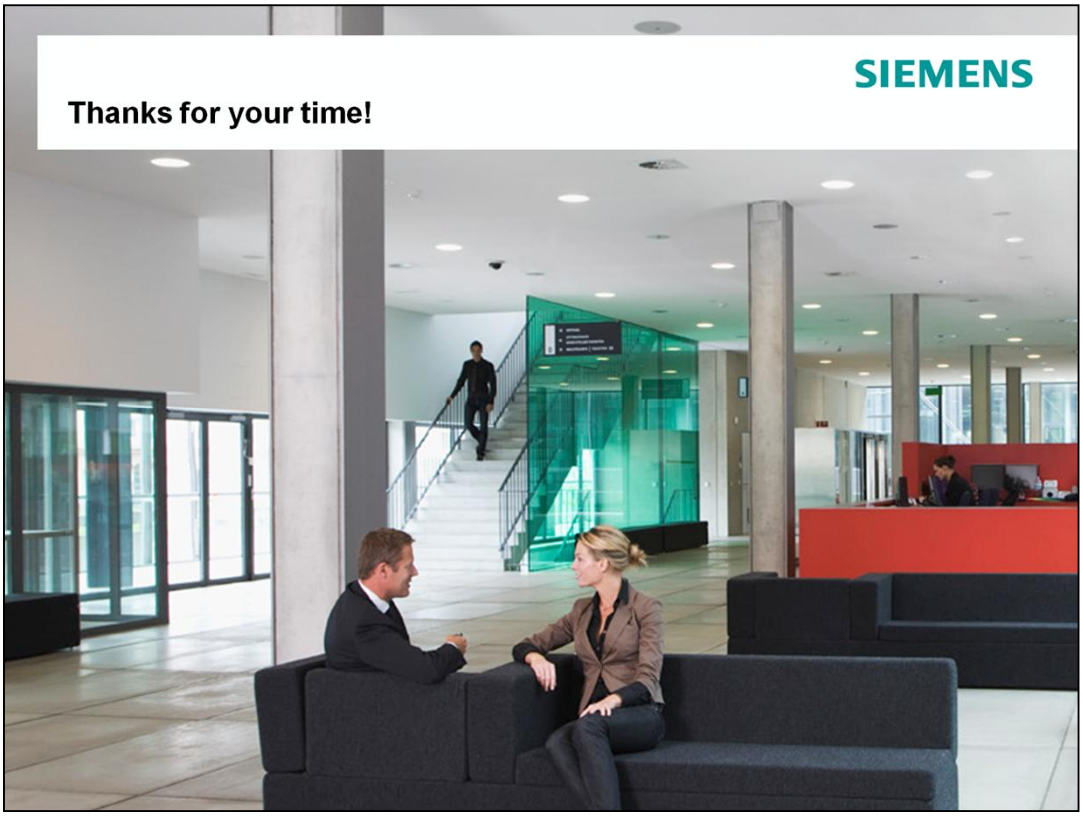
Grüne Luft
Der Atem der Gebäude: Fraunhofer SCS und Siemens helfen sparen

In Zeiten stark belasteter Umwelt und grassierender Energieknappheit sind Einsparungen von über 50 Prozent nahezu beispiellos. Der Fraunhofer SCS ist es zusammen mit der Siemens-Division Building Technologies (BT) nun gelungen, bei der Belüftung von Gebäuden genau diese substanzielle Einsparung zu erzielen und trotzdem eine hohe Qualität der Anlagen zu sichern.

In einem gemeinsamen Forschungsprojekt optimierten die SCS-Forscher die von Siemens entwickelte Lüftungsregelung AirOptiControl des Gebäudeautomationssystems DESIGO V4.1 auf bahnbrechende Weise. Die intelligente, bedarfsabhängige Regelung führt einem Gebäude in energieeffizienter Weise nur jene Luft zu die es im Augenblick braucht. Im Gegensatz zu konventionellen, nicht bedarfsabhängigen Regelungen kann mit dieser Regelung insbesondere immer dann viel Transportenergie eingespart werden, wenn der Luftbedarf in den versorgten Räumen relativ tief ist.

Die optimierte Ventilatorregelung erzielt aber nicht nur drastische Energieeinsparungen, sondern sichert gleichzeitig einen niedrigen Verschleiß der Lüftungsanlage sowie eine hohe Regelgüte. In einem Gebäude steuern neben

Fraunhofer-Institut für
Integrierte Schaltungen IIS
Am Wolfsmantel 33
91058 Erlangen


SIEMENS
Thanks for your time!

SIEMENS

Appendix

-> Field experience, provided by Daniel Wyss

DESIGO™ V4 Energy functions PX

MUX_101-FB969 / DMUX_101FB965 not available in the firmware

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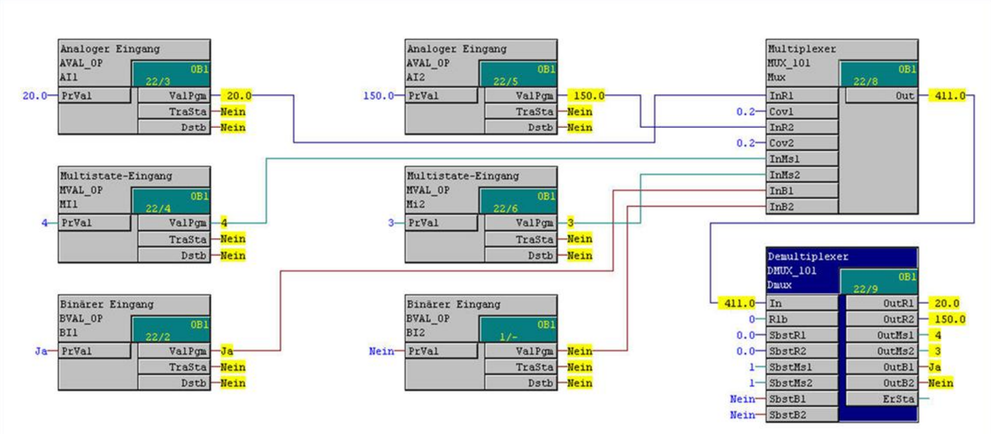
Blocks MUX_101 and DMUX_101 can exchange 15 real / 15 multistate / 15 binary values, typically per BACnet connection (transmission real as a number), blocks must relate to the solution in the CFC



DESIGO™ V4 energy functions PX
Sequence control room

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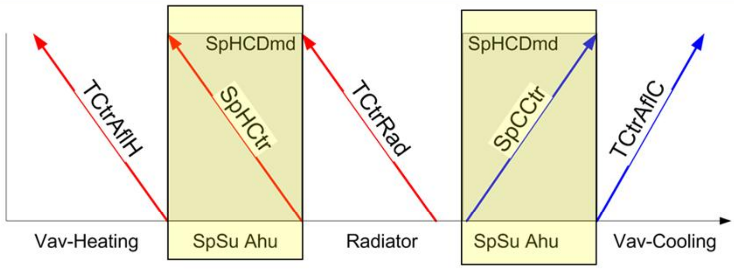


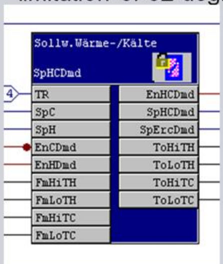
- The setpoints for the ventilation is first adapted. When heating, the radiator is used to heat in the first sequence. Only then is the air volume increased from the minimum air exchange to maximum.

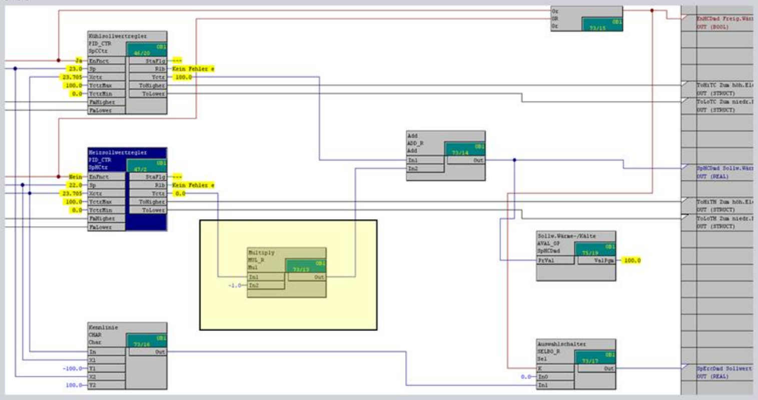
DESIGO™ V4 energy functions PX

Setting air aftertreatment

SIEMENS

The temperature setpoint is transmitted from full heating = -100% / full cooling =100%.
This is transmitted per room to the main plant where it is weighting accordingly as per the setting for air aftertreatment.
The highest value is always determined, so that in a room at 100% cooling, the supply air setpoint is adjusted to minimum or 16 degrees, at -100% full heating, to the maximum limitation or 32 degrees.



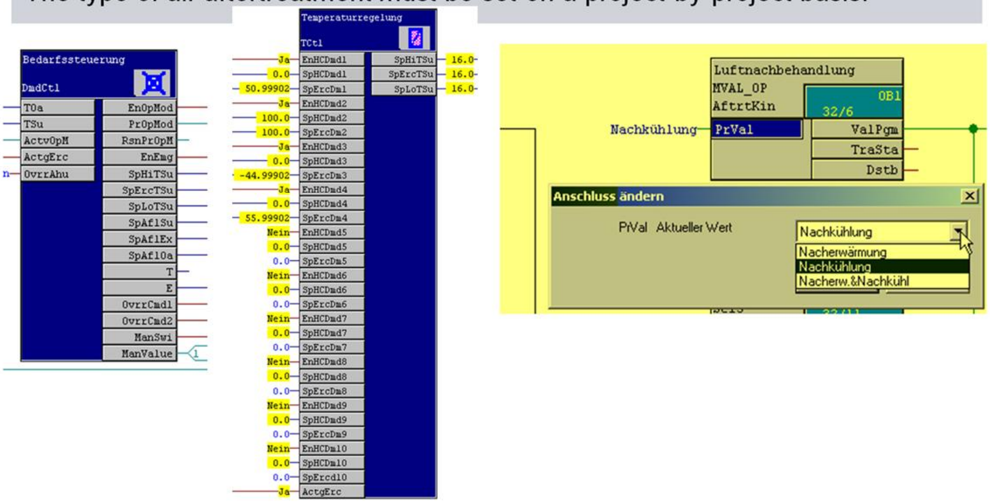


DESIGO™ V4 energy functions PX

Setting air aftertreatment

SIEMENS

The type of air aftertreatment must be set on a project-by-project basis.



DESIGO™ V4 energy functions PX

SIEMENS

Setting air aftertreatment

The type of air aftertreatment must be set on a project-by-project basis. The supply air temperature setpoints are determined differently depending on the type of air aftertreatment.

Reheating:
In the room, or per room, you can (re)heat. Cooling demand has priority in a conflict with heating demand.

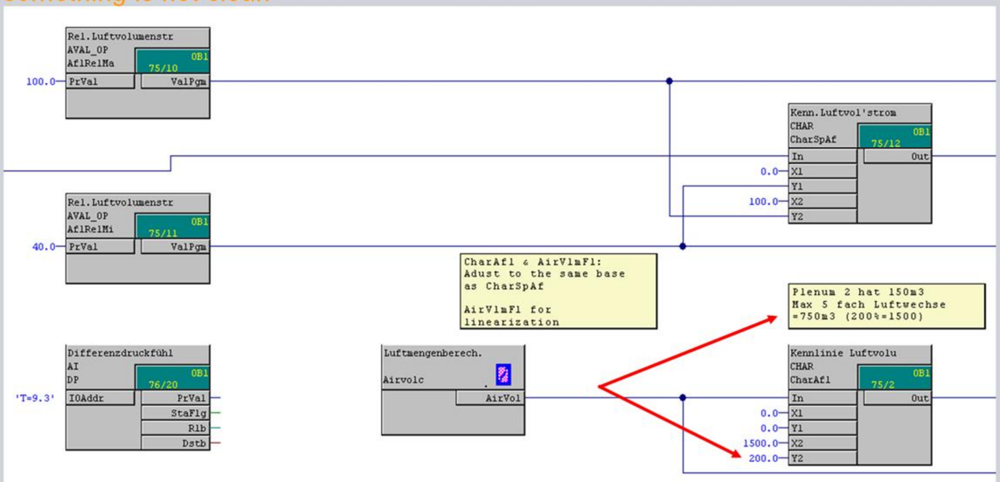
Recooling
In the room, or per room, you can (re)cool. Heating demand has priority in a conflict with cooling demand.

Reheating and recooling:
In the room, or per room, there is (re)heating and (re)cooling. The average demand is considered for a conflict between heating and cooling demand.

DESIGO™ V4 energy functions PX

Control air flow - room

The settings for air flow can be referenced in the expert guide. The 200% setting requires special attention. See example Sennweid. Contact Dani if something is not clear.



DESIGO™ V4 energy functions PX
Control strategy fan variant 1

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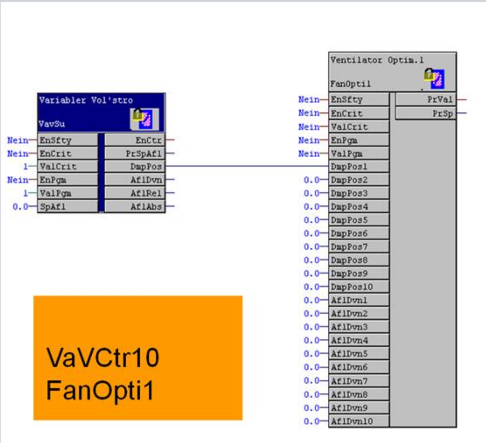
The control strategy fan demand coordination for the damper position of the VAV boxes. PX controls the VAV boxes.



The damper positions of the individual VAV boxes are collected and the fan speed set so that the damper is nearly fully open in at least one room. This variant is preferable to variant (2), since it is easier to understand and fan speed fluctuates less

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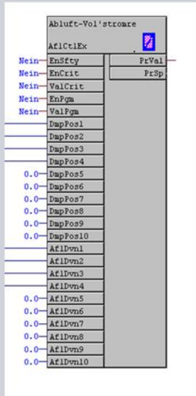
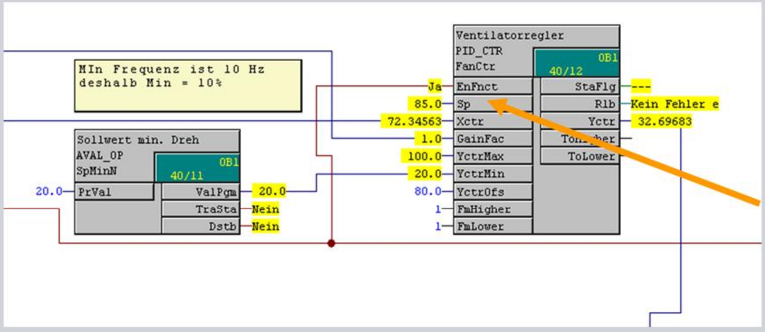
DESIGO™ V4 energy functions PX
Control supply and extract air fan variant 1





DESIGO™ V4 energy functions PX
Control strategy variant 2

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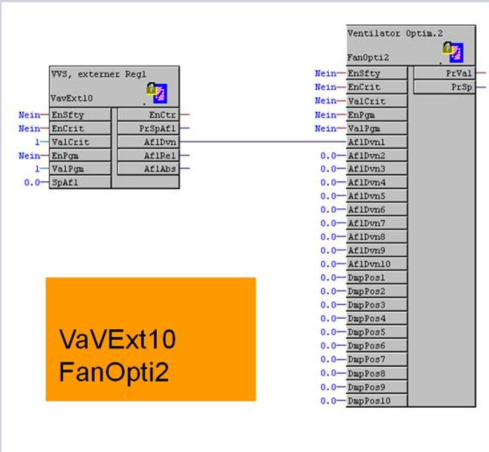
Control strategy fan using volume flow setpoint deviation of the VAV controller.
Control the VAV boxes externally or CPS controller.



The control deviations of "Volume flow setpoints" - "Volume flow actual values" [%] is collected and the fan speed so that the deviation is slightly positive in one room, i.e. under coverage. This under-coverage is kept to a minimum using a special type of speed control

DESIGO™ V4 energy functions PX

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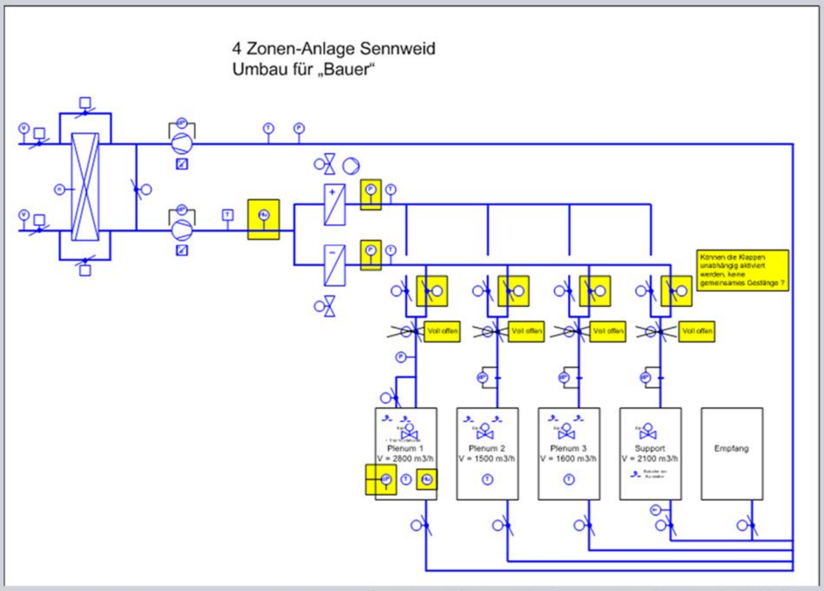
Experience from Steinhausen



DESIGO™ V4 energy functions PX
Experiences from Steinhausen

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Additional expense by renovation

- No standard plant, 2-duct with changeover damers heating/cooling
- No installation of air velocity sensors due to VAV; relatively expensive and very difficult to find the measuring points.
- Controlling air dampers is difficult to say the least.
- Old faults are often discovers during renovation, i.e. faulty dampers, etc.
- Adapt main functions to CHLIB functions, install operating mode converters
- Install presence detectors
- Solution learning curve

Overall impression is excellent

Text

Eco Monitoring

DESIGO - Energy efficient Applications

DESIGO – Energy efficiency applications

RC-SE, December 2012

Petar Georgiev
Application Engineer

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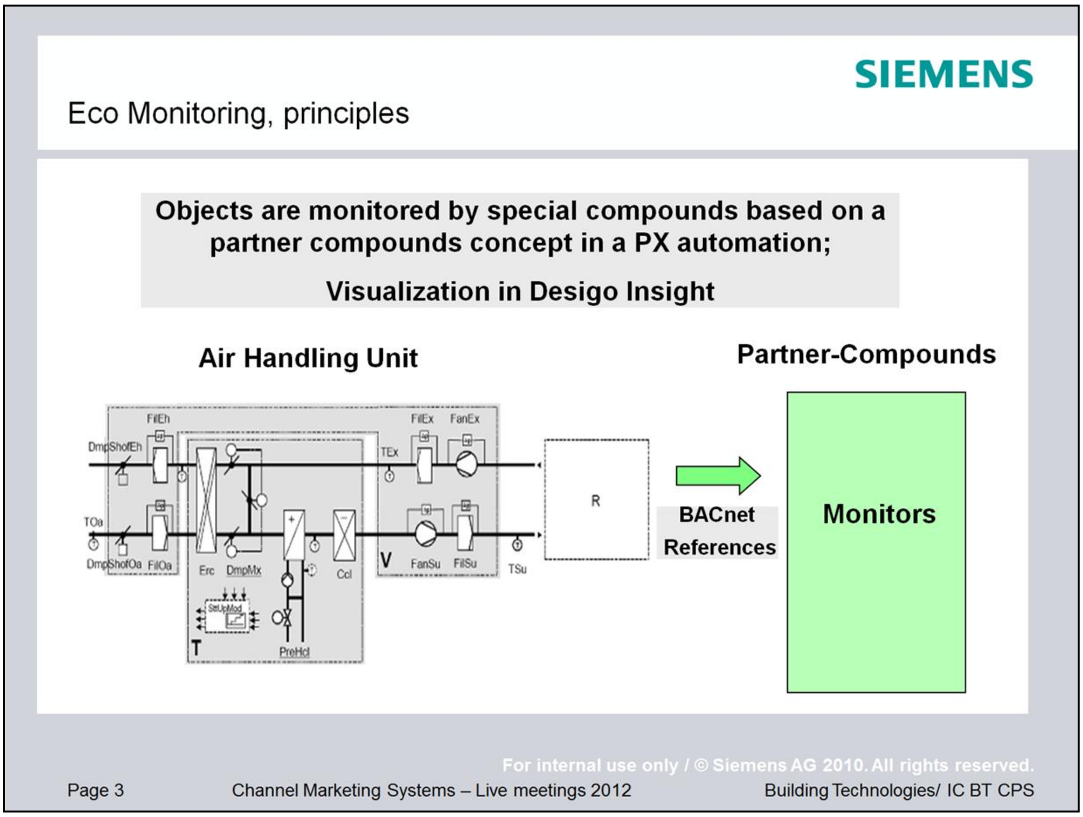
Eco Monitoring

Real-time detection of inefficient plant operation

- **Possible reasons:**
  - Change of building use and operating hours
  - Change of set point value
  - Defective components
  - Manual override or control



New or existing plant is monitored. The only connection between the monitored plant plan and the monitors are BACnet references.

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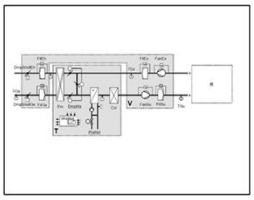
Eco Monitoring, workflow



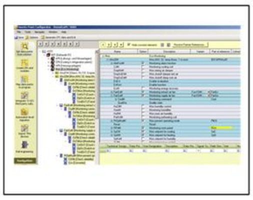
Initial check:

Decision:

What should be monitored?

How?

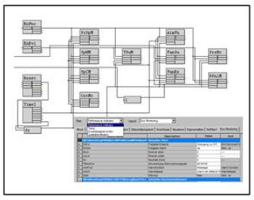
Setting up the limits?



XWorks Plus/CFC:

-Choosing and linking of a proper monitor (out of a library)

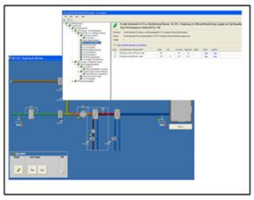
- Setting options and variants (What and How)



CFC:

Setting up the limits

If needed: programming of additional logic (e.g. dynamic limits, some dependencies)

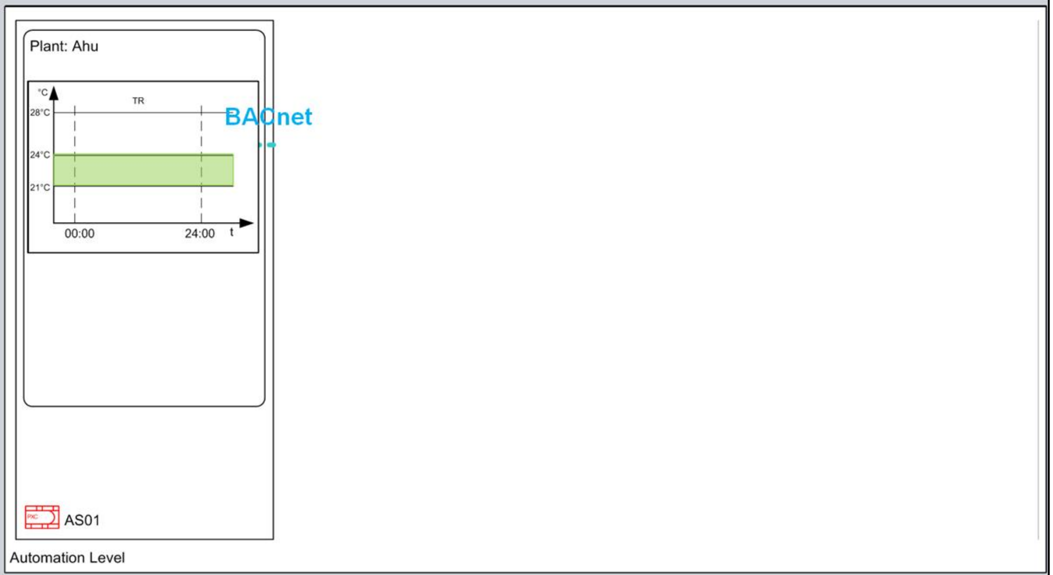


Desigo Insight:

Eco Viewer:
Changing the limits

Plant Viewer:
Displaying monitoring states on plant graphics

Eco Monitoring, monitor for room temperature



Eco Monitoring, monitor for room temperature

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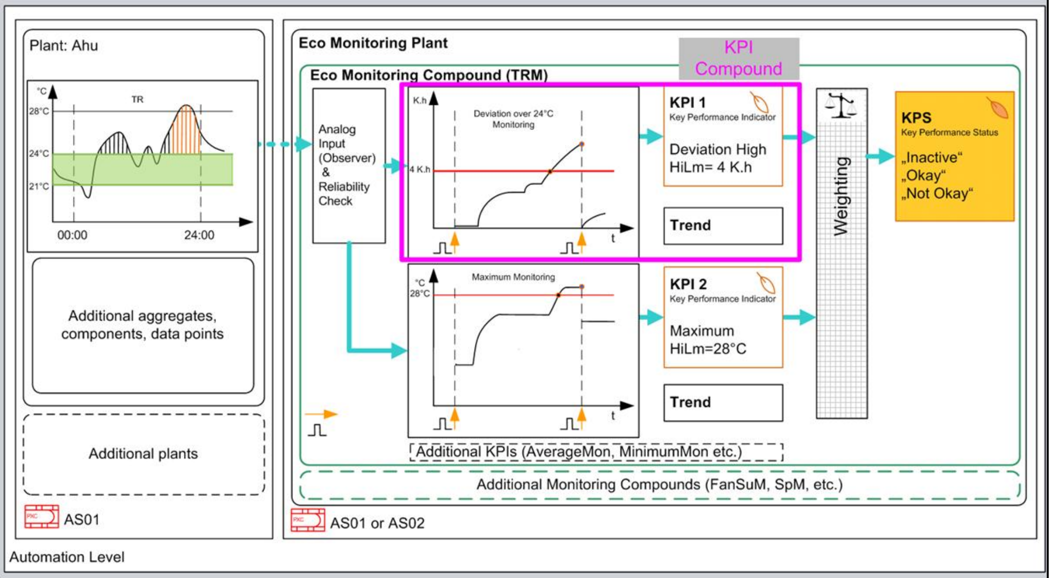

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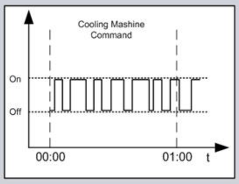
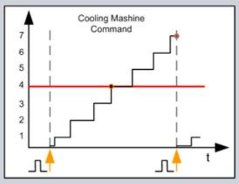
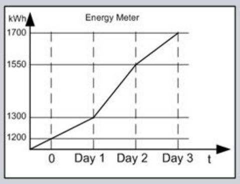
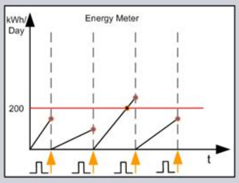
Eco Monitoring, examples for other monitoring functions





Monitoring of switch-on rate of a binary/multistate signal
(Binary Monitor, Multistate Monitor)
e.g. important for cooling machine monitoring





Monitoring of consumption during a period (e.g. daily)
(Counter Monitor)
e.g. counter monitoring

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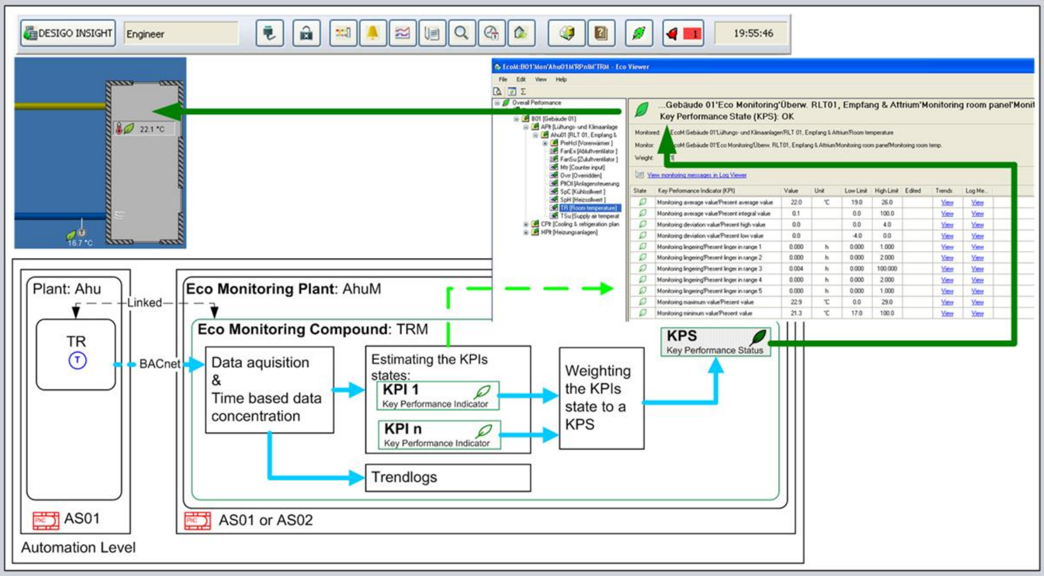
Eco Monitoring, automation + management level (Eco Viewer)



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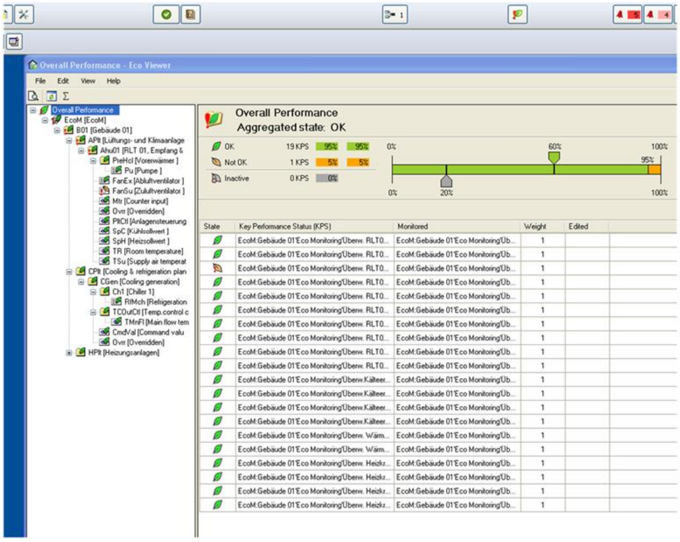
Eco Monitoring, Eco Viewer in Desigo Insight



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Eco Monitoring, Main Messages

Main Messages:

•Real time monitoring

•We have the potential to prevent unnecessary energy consumption and operation

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Eco Monitoring, Demo

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Questions & Answers

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Eco Monitoring, library PXC MON01

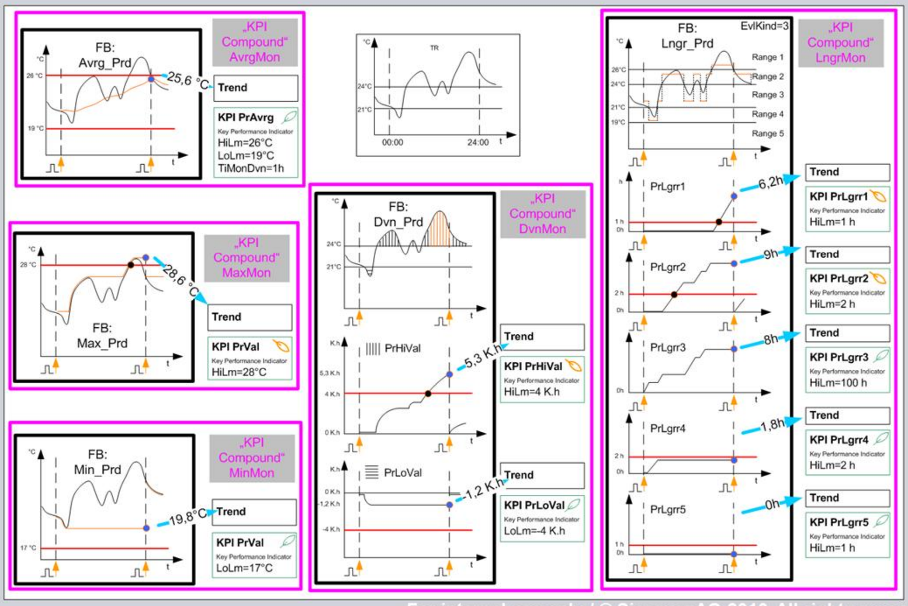
Library: (General part)

- **10 new Firmware Blocks**
- **4 Basic Monitoring Compounds: Amon, Bmon, MsMon, CntMon**

Compatible to CAS Library:

- **about 70 Eco Monitoring Compounds**
- **7 Eco Monitoring Plants**

Eco Monitoring, analog monitor



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h,x – control
Economizer tx2

Demand optimized operation of energy recovery

DESIGO – Energy efficiency applications

RC-SE, December 2012

Author: **Benedikt Schumacher, 3043**

Revision: 1, 19-Nov-2012
Document Status: Approved – valid without signature

Infrastructure & Cities / BT

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Revision History

Rev	Date	Author	Changes, Comments dh1
1	19-Nov-2012	Benedikt Schumacher	Status=Freigegeben - ohne Unterschrift gültig

Bild 2

---

dh1 How to remove or insert table rows?
- right mouse click
- Delete Rows
- Insert Rows (befor the selected row)

Use Toolbox > Template Setup to update a template and the revision history for the template.
Donat Hutter; 2008-02-29

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Introduction/contents

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Development history

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Development history (I)

1977: **Enthalpy control (state of the art)**

- Enthalpy strategy for energy recovery
- Temperature and humidity control with uncoordinated neutral zones

1993: **Cost scale line cooling/steam (Baumgarth)**

- Improvement to the enthalpy strategy when using modulating controlled steam humidifiers

1996: **tx2 (Staefa Control Systems)**

- Simulation-based development of an optimized solution for energy recovery control
- Integrated approach replaces enthalpy strategy
- Coordinated setpoint calculation within the comfort field
- Energy recovery strategy in the tx level is outside any control sequence
- Patent registered

1997: **Integral RS**

- Economizer tx2 for Integral RS, implemented based on the cascade sequence controller standard by Staefa Control Systems

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Development history (II)

1998: **Visonik (I)**

- Economizer tx2 for Visonik, implemented based on cascade sequence controller standard by Staefa Control Systems

1999: **Unigyr**

- Economizer tx2 for Unigyr, implemented using the Unigyr cascade sequence controller

2000: **Visonik (II)**

- Economizer tx2 for Visonik, implemented using Visonik cascade sequence controller

2003: **Desigo V2.2**

- Economizer tx2 for Desigo PXC, implemented using Desigo cascade sequence controller, energy recovery position calculation using existing FW library blocks, no delivery with the HQ library

30.03.2009: **Desigo V4.0**

- Economizer tx2 for Desigo PXC, implemented using Desigo cascade sequence controller and new blocks to calculate energy recovery position
- Cockpit for online monitoring of the function applying model-based energy consumption calculations for conventional energy recovery control strategies

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Function

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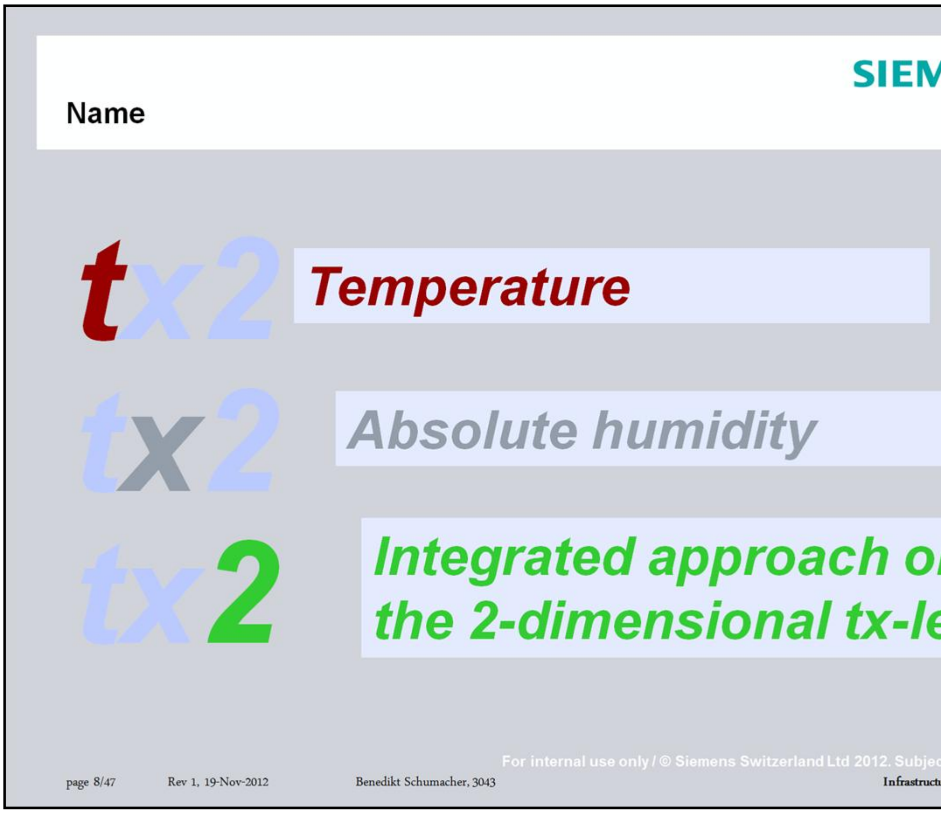
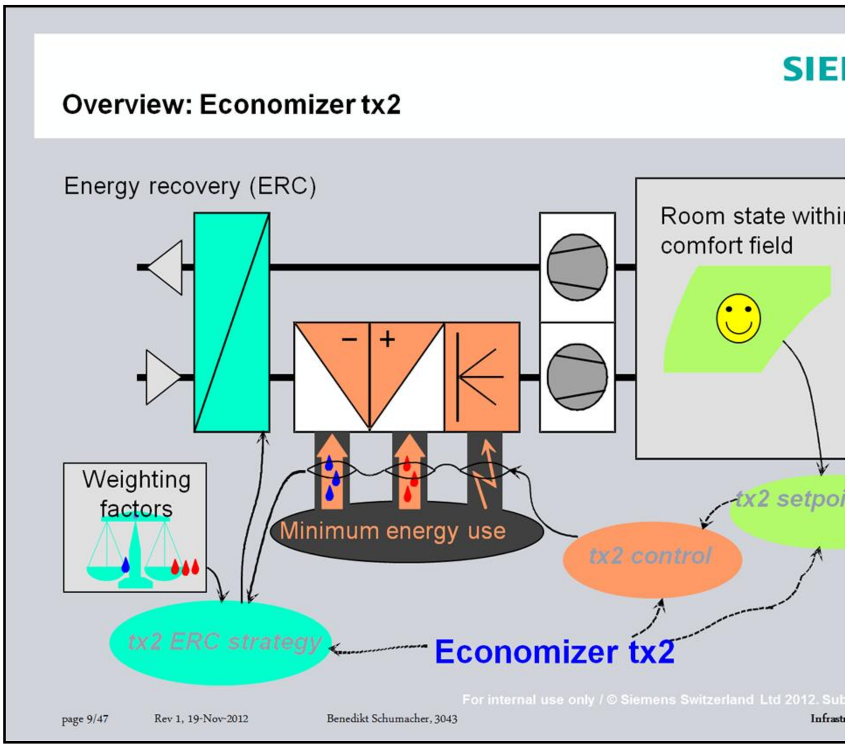


The break out of t-x-2



1. Comfort field: The **Economizer tx2** operates the air conditioning so that the room temperature and room humidity is always within the comfort field.
2. Setpoint processing: Using the comfort field, the setpoint processing module in the Tx2 calculates the optimum setpoints for control.
3. Control: This module controls energy use on the plant.
4. Energy recovery strategy: This module evaluates energy use on the plant to calculate the optimum use of energy recovery. The module considers the real energy cost situation using weighting factors.

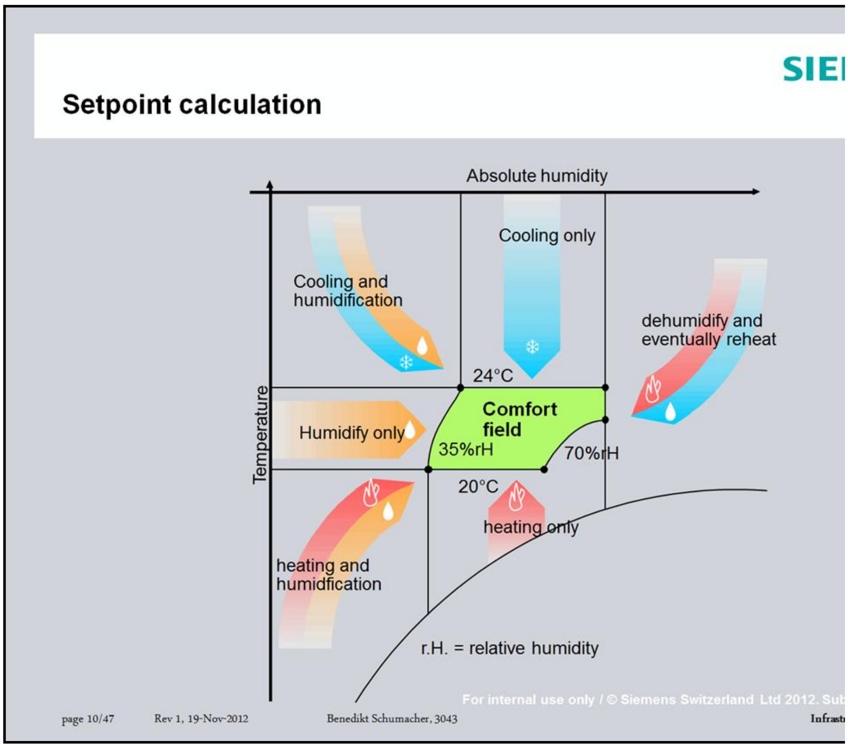
Summary:

The Economizer tx2 optimizes plant operation by

(1) Taking advantage of the comfort field as much as possible – but not at the expense of comfort

(2) The outside air is precondition using energy recovery to minimize energy costs.

Traditional control is unable to operating the plant in such an uncompromising manner.



SIE
Setpoint calculation
Absolute humidity
Cooling only
Cooling and humidification
dehumidify and eventually reheat
24°C
Comfort field
Humidify only
35%rH
70%rH
Temperature
20°C
heating only
heating and humidfication
r.H. = relative humidity
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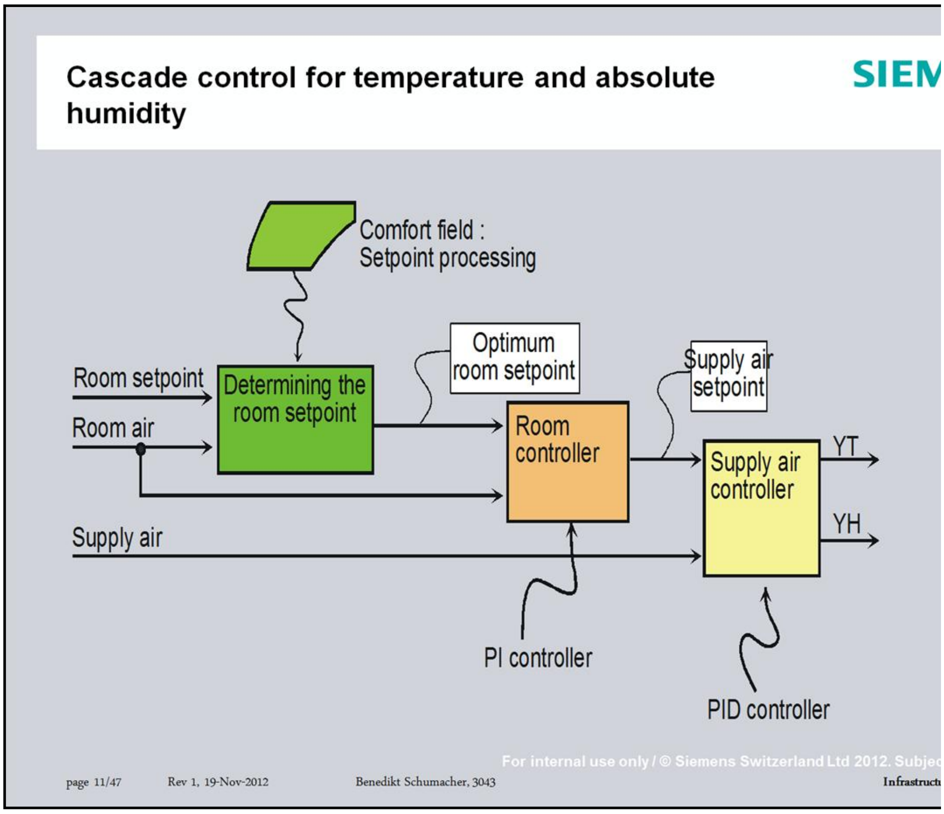
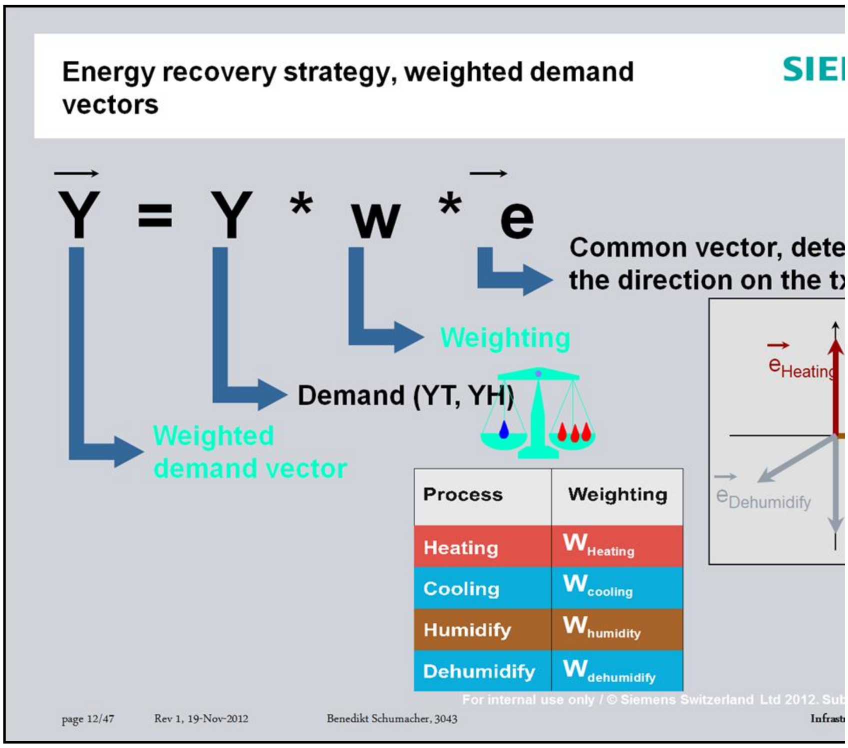
Rev 1, 19-Nov-2012
Benedikt Schumacher, 3043



Cascade control

Separate cascade controller for temperature and absolute humidity

Calculate demand signals YT and YH


Energy recovery strategy, weighted demand vectors
SIE
Y = Y * w * e
Common vector, dete
the direction on the t
Weighting
Demand (YT, YH)
Weighted demand vector
Process
Weighting
Heating
W Heating
Cooling
W cooling
Humidify
W humidity
Dehumidify
W dehumidify
e Heating
e Dehumidify
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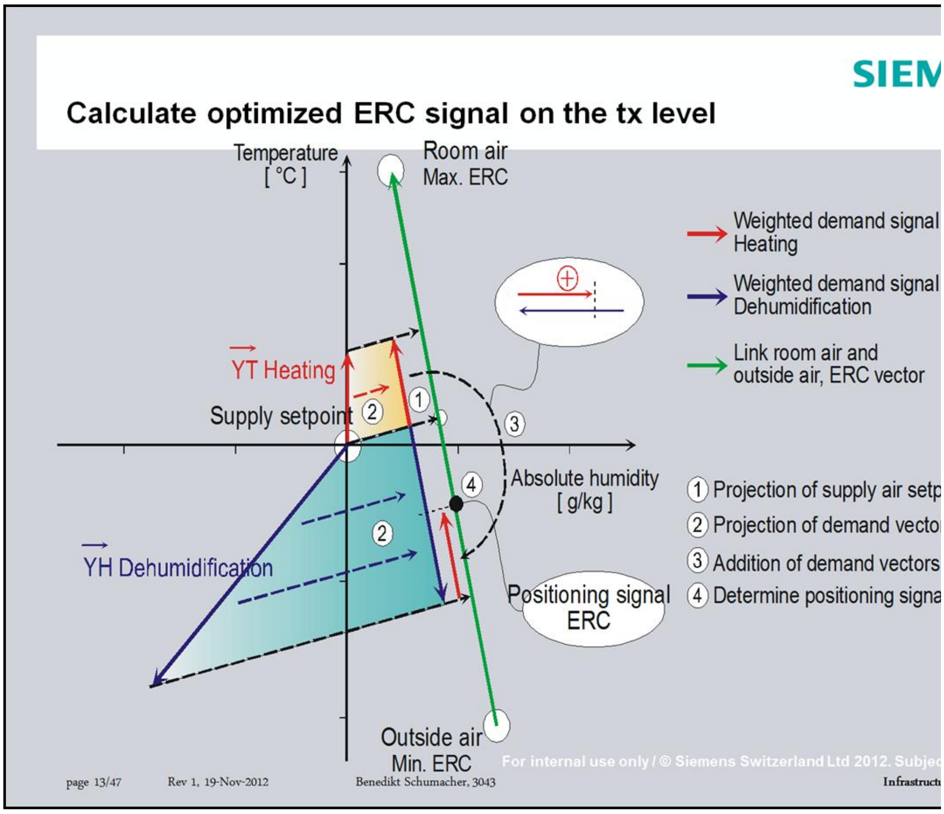
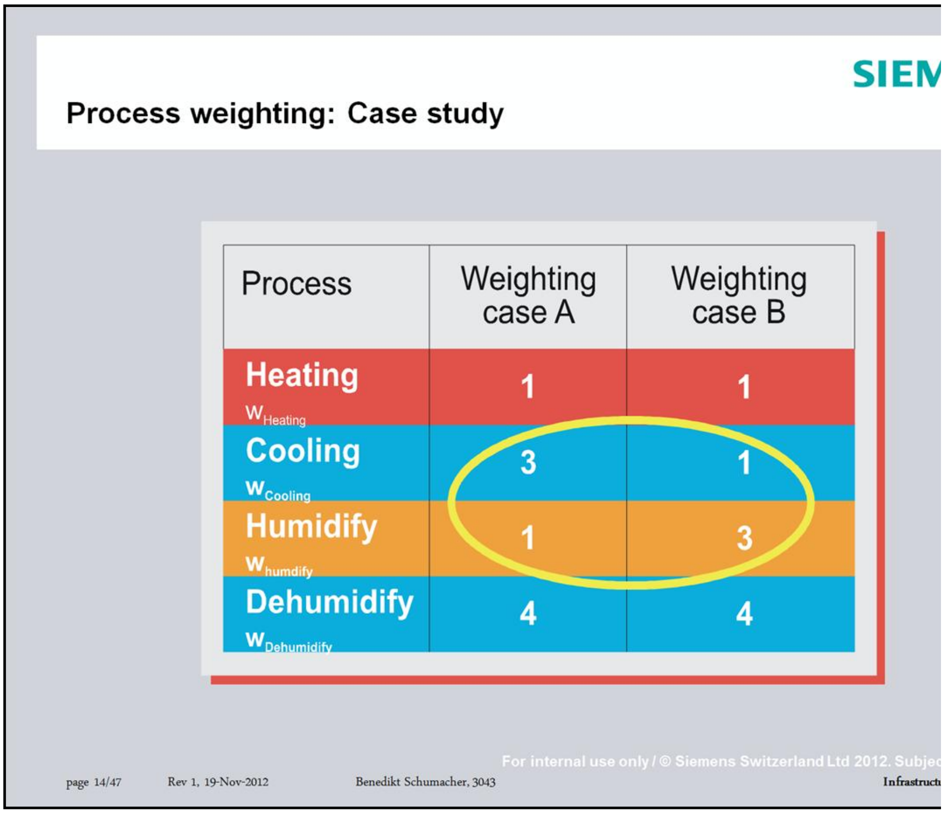


Illustration of tx2 ERC strategy



Starting point:

Warm, dry weather, room-side increase in temperature and humidity; on the plant side cooling and humidity demand

Case A:

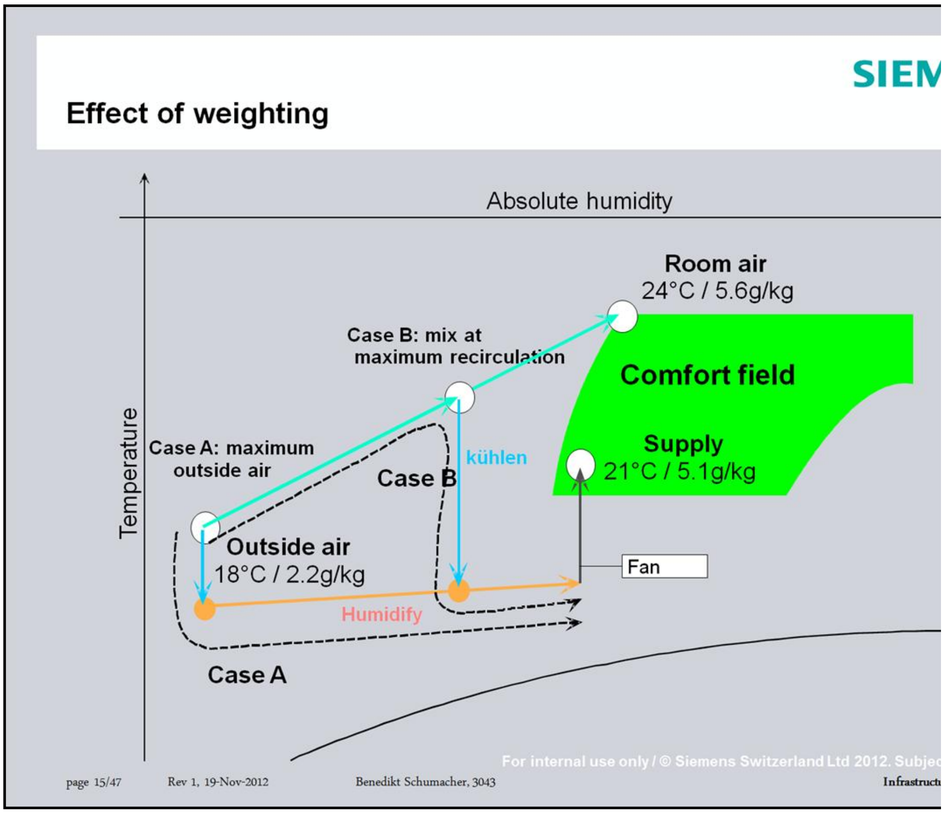
Cooling with expensive refrigeration machine, humidification using inexpensively generated vapor

Case B:

Cooling using lake water, humidify using vapor

Weighting:

The table outlines consideration of energy costs

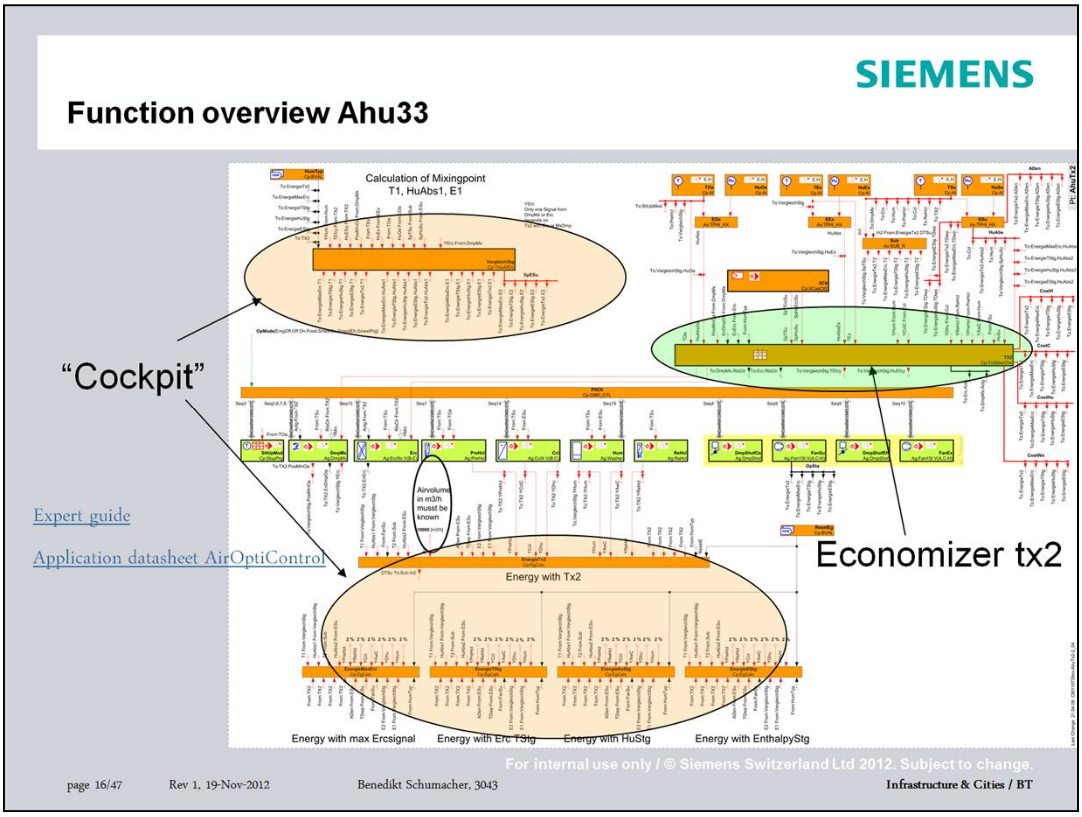


Case A:

The expensive cooling process is relieved to optimize overall costs by operating the air conditioning unit at maximum outside air

Case B:

The cheap cooling process is used in support of optimizing overall costs by operating at maximum energy recovery



Present Visio

Benchmarking

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Benchmarking with simulation, key values

A/C plant:

Full A/C plant or plant with heating, cooling, humidification

Point control:

Room setpoint 22.5°C, 45% r.H.

Setpoint field control:

Room setpoint field 22.5±1.5°C, 45±15% r.H.

Weather:

Central Switzerland

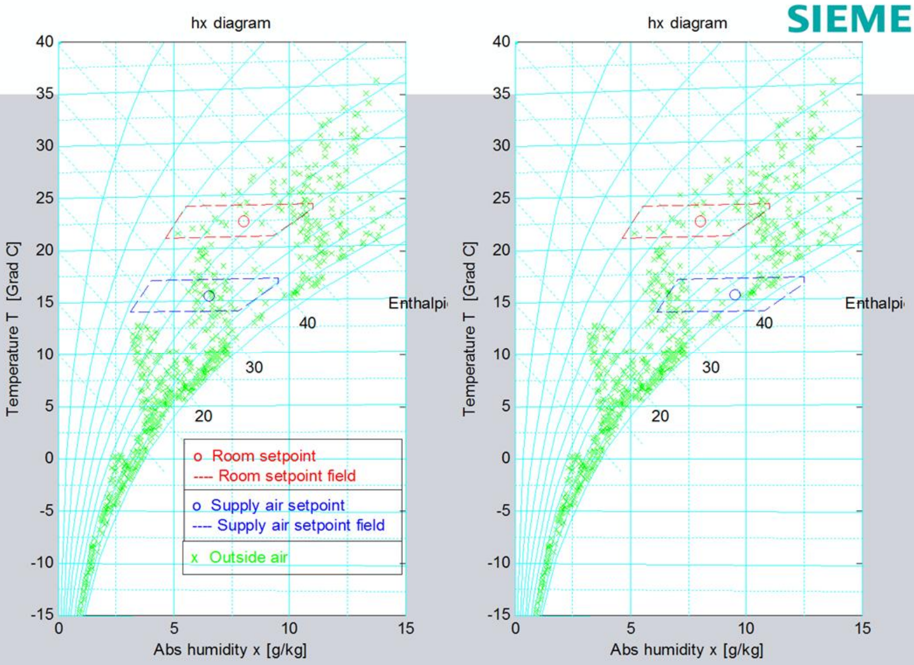
Equipment:

Steam humidifier, heating coils (centralized heat production, natural gas)

Compressor refrigeration plant (centralized)

Room load:

1. Q>0 (25W/m2), W>0 (0.005g/s·m2)
2. Q>0 (25W/m2), W<0 (-0.005g/s·m2)
3. Q=0, W>0 (0.005g/s·m2)
4. Q=0, W<0 (-0.005g/s·m2)



Load case 1: Q>0 (25W/m2), W>0 (0.005g/s·m2)

Load case 2: Q>0 (25W/m2), W<0 (-0.005g/s·m2)

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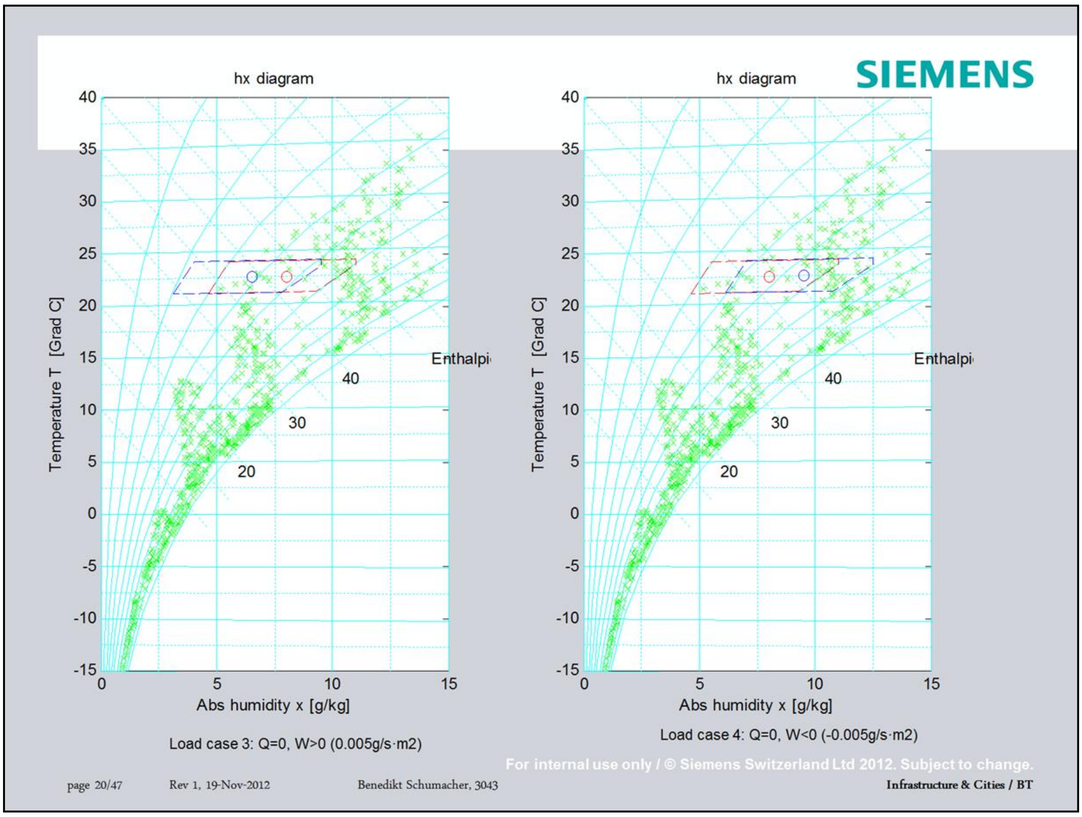
hx diagram
Temperature T [Grad C]
Abs humidity x [g/kg]
Enthalpi
20
30
40
Load case 3: Q=0, W>0 (0.005g/s·m2)
hx diagram
Temperature T [Grad C]
Abs humidity x [g/kg]
Enthalpi
20
30
40
Load case 4: Q=0, W<0 (-0.005g/s·m2)
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Benchmark results (I): ERC in temperature sequence

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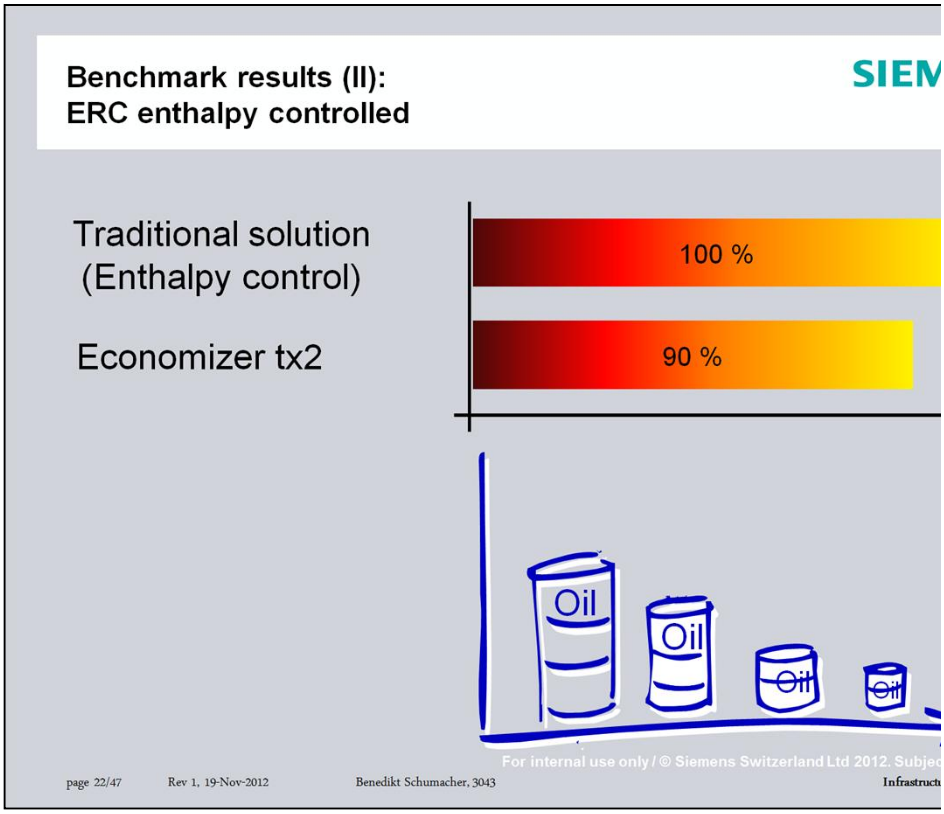
Load Q: Heat load W: Humidity load	Setpoint field + conventional ERC control (ERC in temperature sequence) Annual savings potential compared to point control in [%]	Setpoint field + TX2 ERC control Additional annual savings potential compared to "Setpoint field + conventional ERC control" in [%]
Q>0 W>0	ca. 75%	10%-15%
Q>0 W<0	ca. 45%	1%-2%
Q=0 W>0	ca. 55%	4%-8%
Q=0 W<0	ca. 35%	1.5%-5%



Basis for comparison:

The comparison is based on the results of the simulation

Simulation

Real weather from a weather station (here: Zurich)

Operating hours: Daily from 7 am to 7 pm

Benchmark results (II):
tx2 with and without setpoint field, VCS (Stork)

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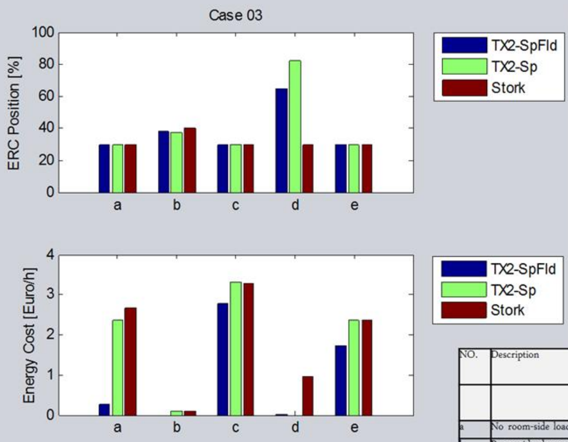

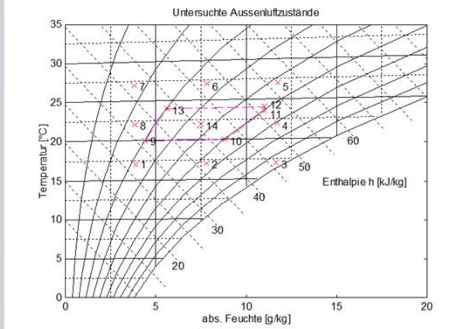

NO.	Description	Change in temp.	Change in absolute humidity
		K	g/kg
a	No room-side loads	0	0
b	Room-side decrease in temperature and humidity	-2	-1
c	Room-side decrease in temperature and increase in humidity	-2	+1
d	Room-side increase in temperature and decrease in humidity	+2	-1
e	Room-side increase in temperature and humidity	+2	+1

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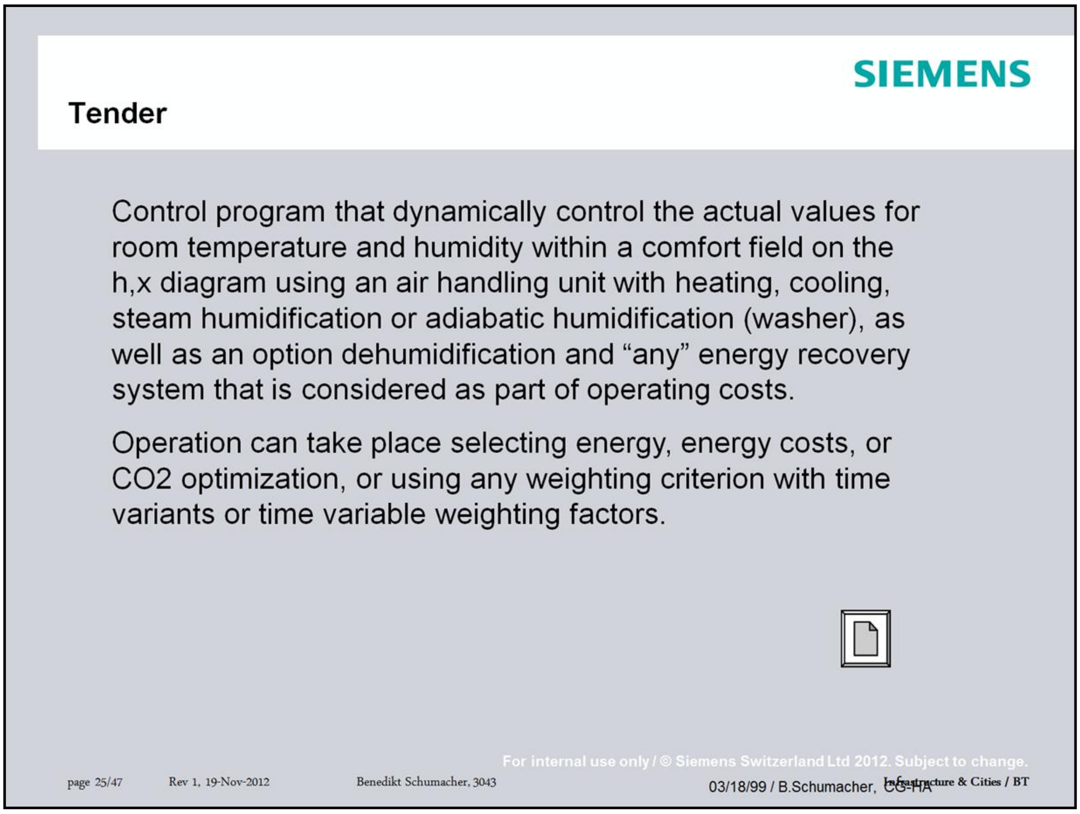

Suchen Sie eine Regelprogramm für eine Klimaanlage mit den Prozessen Heizen, Kühlen, Dampf- oder adiabatischer Befeuchtung (z.B. Wäscher), sowie Entfeuchten und beliebigem Energierückgewinnungssystem?

Und muss die Anlage die Raumtemperatur und Raumfeuchte innerhalb eines Behaglichkeitsfeldes im h,x-Diagramm dynamisch regeln, um optimale Arbeits- bzw. Prozessbedingungen zu gewährleisten?

Und ist Ihnen die Optimierung des Energieeinsatzes oder der Energiekosten von Bedeutung?

Erfinden Sie keine neue Lösung, brauchen Sie den Economiser tx2 !

Coverage

Plant with steam humidification?
Are covered. Less expensive process steam can be considered in the weighting factors and result in an advantage for Tx2 under certain circumstances.

tx2 with a complete heat recovery plant?
Is not covered. One requirement is that ERC does not cause relevant costs compared to the thermal air handlings with heating coils, cooling coils, and humidifier.

Delivery scope

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Delivery scope

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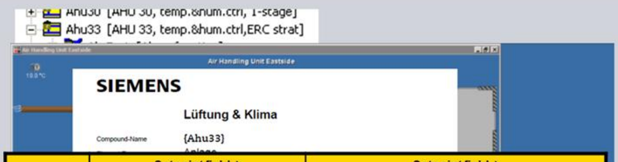
As of Desigo V4.0, “Economizer tx2” delivery includes the following:

- 1 plant solution in the CAS Library, a total of ca. 10 new compounds
- Visualization on Desigo Insight and “Cockpit” for online functional monitoring
- Technical documentation
  - Reference manual for Compound Library PXC-CAS
  - Expert guide on Compound Libraries
- Sales documentation
  - Application datasheet
- (Demonstration application)



Load Q: Head load W: Humidity load	Setpoint field + conventional ERC control (ERC in the temperature sequence) Annual savings potential compared to point control in [%]	Setpoint field + TX2 ERC control Additional annual savings potential compared to “Setpoint + conventional ERC control” in [%]
Q>0 W>0	ca. 75%	10%-15%
Q>0 W<0	ca. 45%	1%-2%
Q=0 W>0	ca. 55%	4%-8%
Q=0 W<0	ca. 35%	1.5%-5%

Demonstration application operates only with Matlab license

Desigo PX Library
new compounds as of Desigo V4.0

Tx2MxeCho	tx2 Maximum-Economy changeover
EgCalc	EgCalc Energy and output calculation
EgWg	Energy weighting
CostWCalc	Water cost calculation

Desigo PX Library
new blocks as of Desigo V4.0

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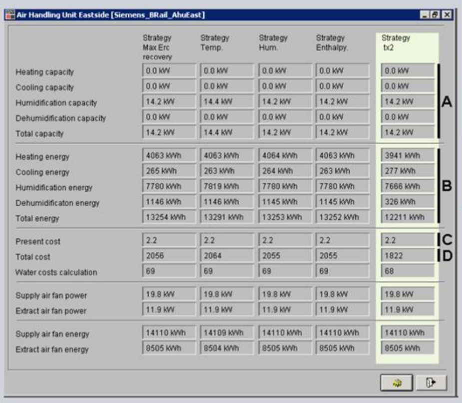
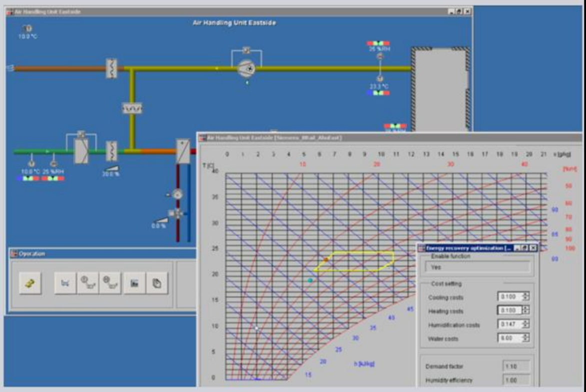
Desigo Insight Library

Genies / Supergenies

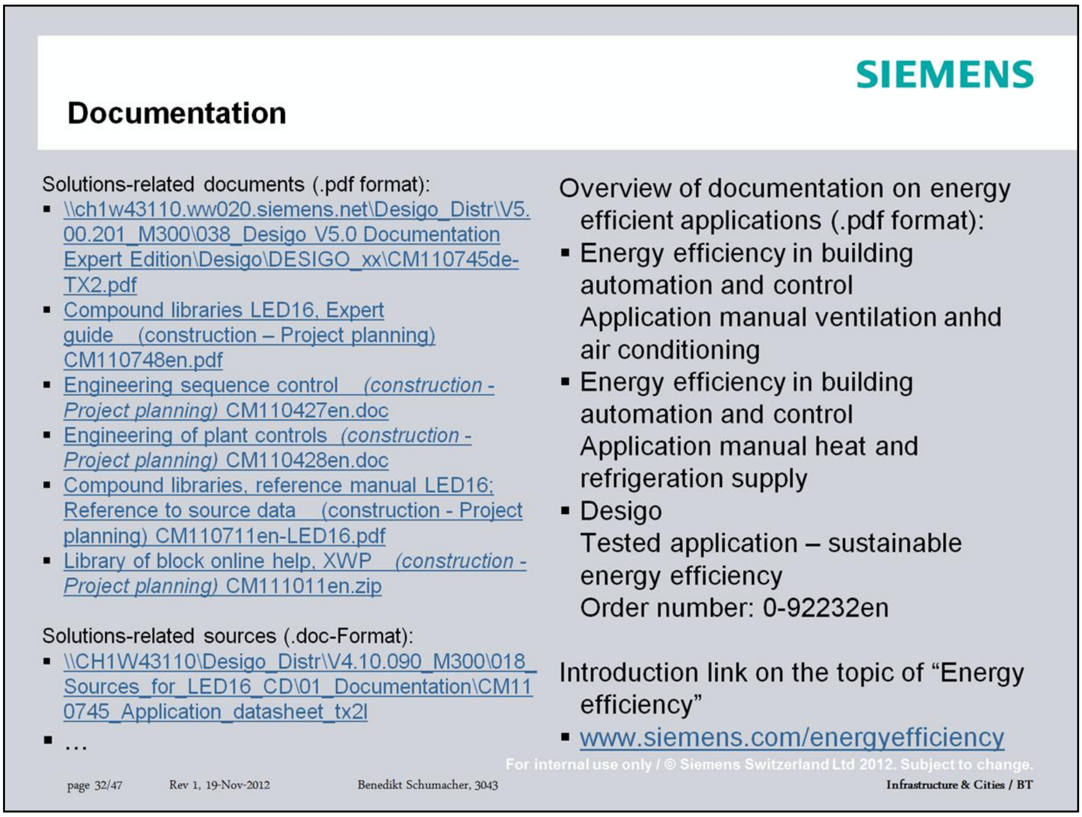


Air Handling Unit Eastside [Siemens_BRail_AhuEast]

	Strategy Max Erc recovery	Strategy Temp.	Strategy Hum.	Strategy Enthalpy.	Strategy tx2	
Heating capacity	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW	A
Cooling capacity	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW	
Humidification capacity	14.2 kW	14.4 kW	14.2 kW	14.2 kW	14.2 kW	
Dehumidification capacity	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW	
Total capacity	14.2 kW	14.4 kW	14.2 kW	14.2 kW	14.2 kW	
Heating energy	4063 kWh	4063 kWh	4064 kWh	4063 kWh	3941 kWh	B
Cooling energy	265 kWh	263 kWh	264 kWh	263 kWh	277 kWh	
Humidification energy	7780 kWh	7819 kWh	7780 kWh	7780 kWh	7666 kWh	
Dehumidificaton energy	1146 kWh	1146 kWh	1145 kWh	1145 kWh	326 kWh	
Total energy	13254 kWh	13291 kWh	13253 kWh	13252 kWh	12211 kWh	
Present cost	2.2	2.2	2.2	2.2	2.2	C
Total cost	2056	2064	2055	2055	1822	D
Water costs calculation	69	69	69	69	68	
Supply air fan power	19.8 kW	19.8 kW	19.8 kW	19.8 kW	19.8 kW	
Extract air fan power	11.9 kW	11.9 kW	11.9 kW	11.9 kW	11.9 kW	
Supply air fan energy	14110 kWh	14109 kWh	14110 kWh	14110 kWh	14110 kWh	
Extract air fan energy	8505 kWh	8504 kWh	8505 kWh	8505 kWh	8505 kWh	



Cockpit



Link in document: Reference manual, expert guide, application datasheet

Experiences

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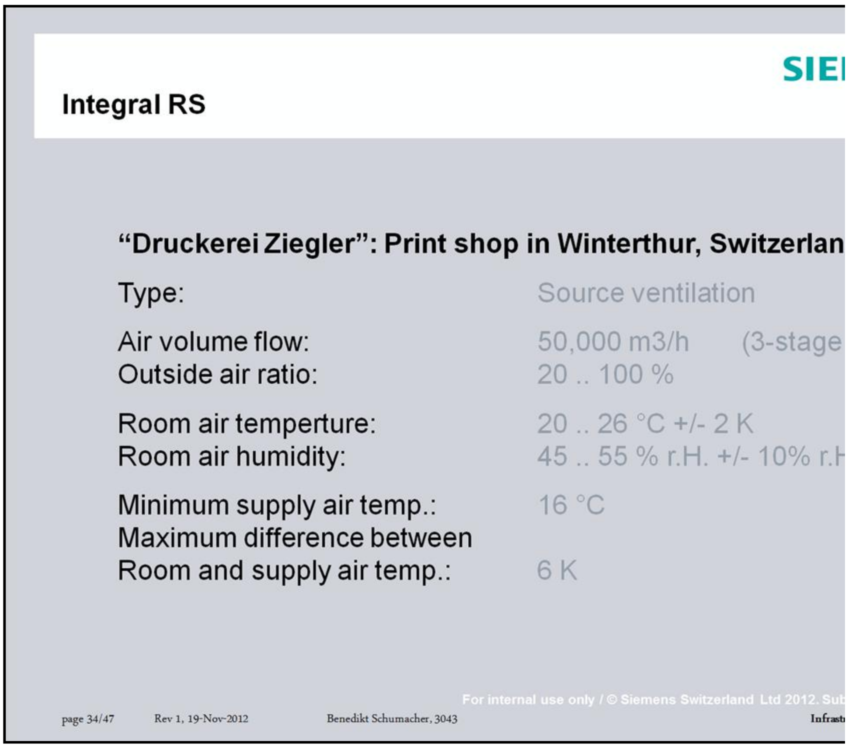
Content

- Development history
- Function
- Benchmarking
- Use
- Delivery scope
    - Desigo PX Library
    - Desigo TRA Library
    - Desigo Insight Library
    - Documentation
    - Demo
- **Experiences**
- Advantages, customer benefits
- Background information

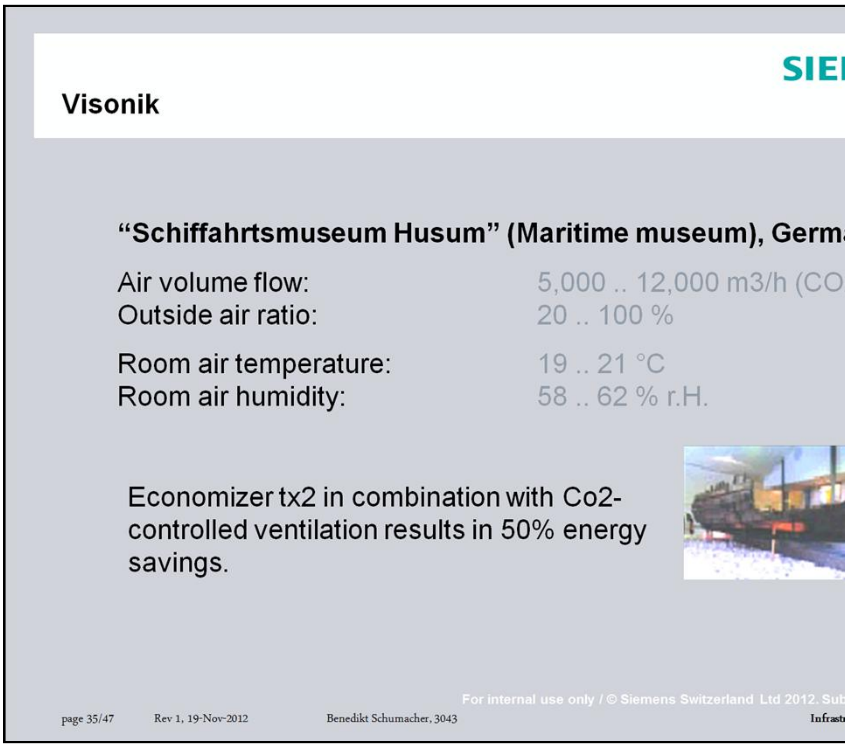


Ziegler Druck in Winterthur Schweiz.

Klimatisierte Halle für Grossdruckmaschinen Rotations-Rollenoffset, in Betrieb seit Sept. 1997.

Kommentar des technischen Verantwortlichen:
Einfach Anlagenbedienung und gutes Anlagenverhalten - die Anlage arbeitet ohne manuelle Eingriffe, wie das bei den anderen konventionell betriebenen Anlagen im gleichen Gebäude häufig der Fall ist.

Einbindung der adiabatischen Kühlung.



Schiffahrtsmuseum Husum, Schleswig Holstein.

Museumhalle mit konserviertem Lastensegler.

Die Energieeinsparung steht im Verhältnis zum erwarteten berechneten Energieverbrauch.

Enge Toleranzen und hoher Komfort gefordert.

Guter und sehr energie-effizienter Anlagenbetrieb.

Economiser tx2 in Verbindung mit CO2-Regelung.

Die Anlage regelt das Klima zur Konservierung eines alten Schiffes (Lastensegler). Das Schiff wurde in eine Zuckerlösung getaucht und muss nun getrocknet werden.

Schiffahrtsmuseum Husum, Schleswig Holstein.

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Advantages, customer benefits

Content

- Development history
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    - Desigo TRA Library
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    - Documentation
    - Demo
- Experiences
- **Advantages, customer benefits**
- Background information

Advantages

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- Comfort control maintains temperature and humidity limits
- Cost-optimize use of available energy
- Monetary depiction of plant efficiency on the control cockpit. In other words, energy consumption of conventional ERC control response is compared to values from idealized process and calculated versus tx2 and can be displayed using the prepared Genies
- Modularly designed standard library applications, including graphics for plant operation on Desigo Insight, result in simple engineering and commissioning

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Customer benefits

- Suitable for existing plants, since the optimization can be achieved using purely control-technical measures without costly modifications to plant hardware
- Reduction in costs for air conditioning without a loss of comfort. Costs may include energy consumption, energy costs, CO2 emissions, etc.
- Cost-optimization by considering energy rates
- Concrete means for sustainable reductions in CO2, thanks to energy savings
- Versus individual optimization solutions, time and cost savings during engineering, commissioning, and operational phases as well as lower service costs thanks to tested applications and detailed documentation
- Meets EN 15232 at the highest energy class and increases the value of the plant for any future sale of the building

Background information

SIEMENS

Content

- Development history
- Function
- Benchmarking
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- Delivery scope
  - Desigo PX Library
  - Desigo TRA Library
  - Desigo Insight Library
  - Documentation
  - Demo
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- Advantages, customer benefits
- **Background information**

Why is tx2 better? Where do the savings come from?

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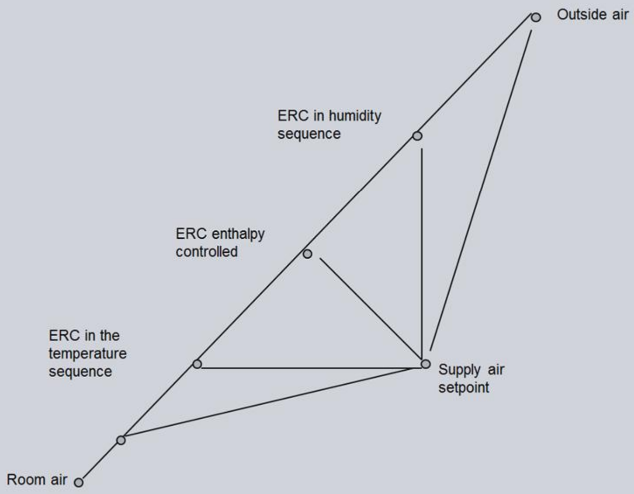
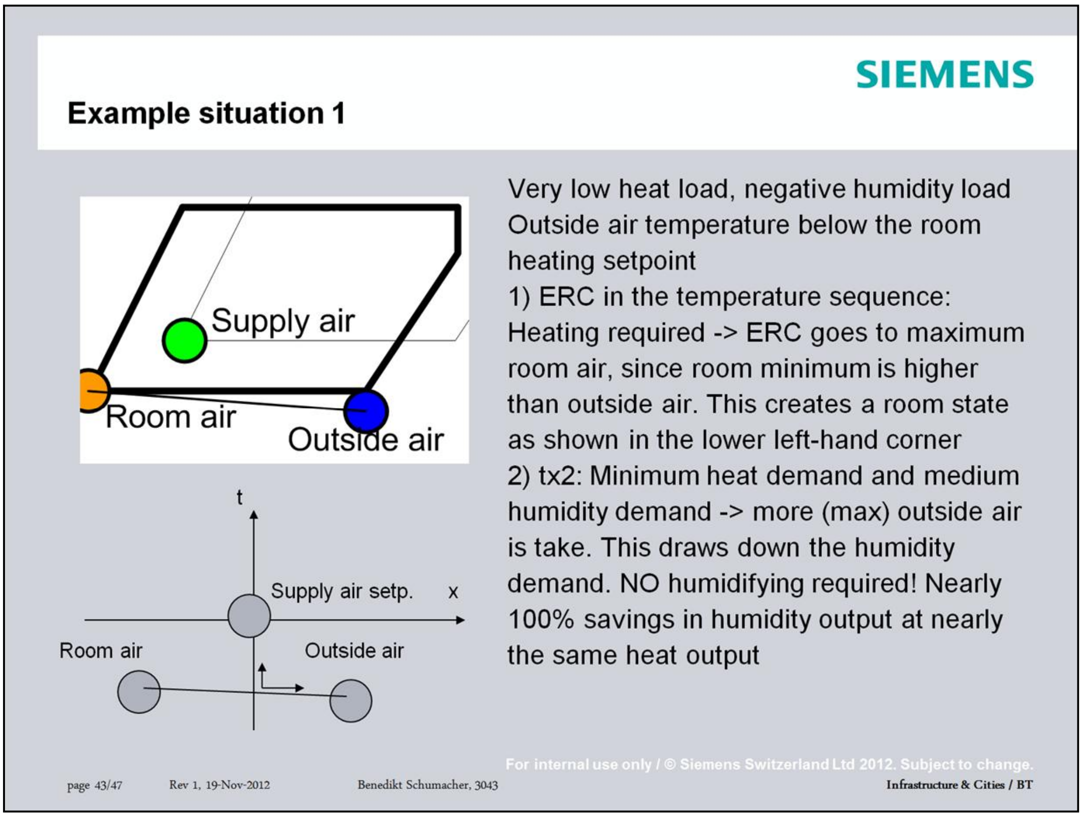
- Outside the sequence
- Weighting factors
- Taking advantage of the setpoint field
- Modulating process, without the typical hysteresis for ERC control action changeover
- Absolute humidity control

SIEMENS

Comparison to conventional processes





2) At that moment where the ERC takes on 100% outside air, the sequence switches from humidify to dehumidify.

While the supply air-humidity demand declines in the sequence, the room temperature moves to the right. This moves the supply air setpoint humidify toward minimum supply air humidity and moves the ERC position in the direction of room air due to the declining supply air humidity demand.

Balance is achieve as soon as the supply air temperature demand corresponds to the (virtual) humidity demand

Time series images: Starting point at max room air mixing, transition, balance.

Reference variable for energy savings, comparison using AirOptiControl

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Economizer TX2

- Thermal air handling is the reference system
- Ca. 5 - 10% in thermal energy savings are possible, depending on the starting point (comparison of control strategy) and load situation, under special circumstances, even more.

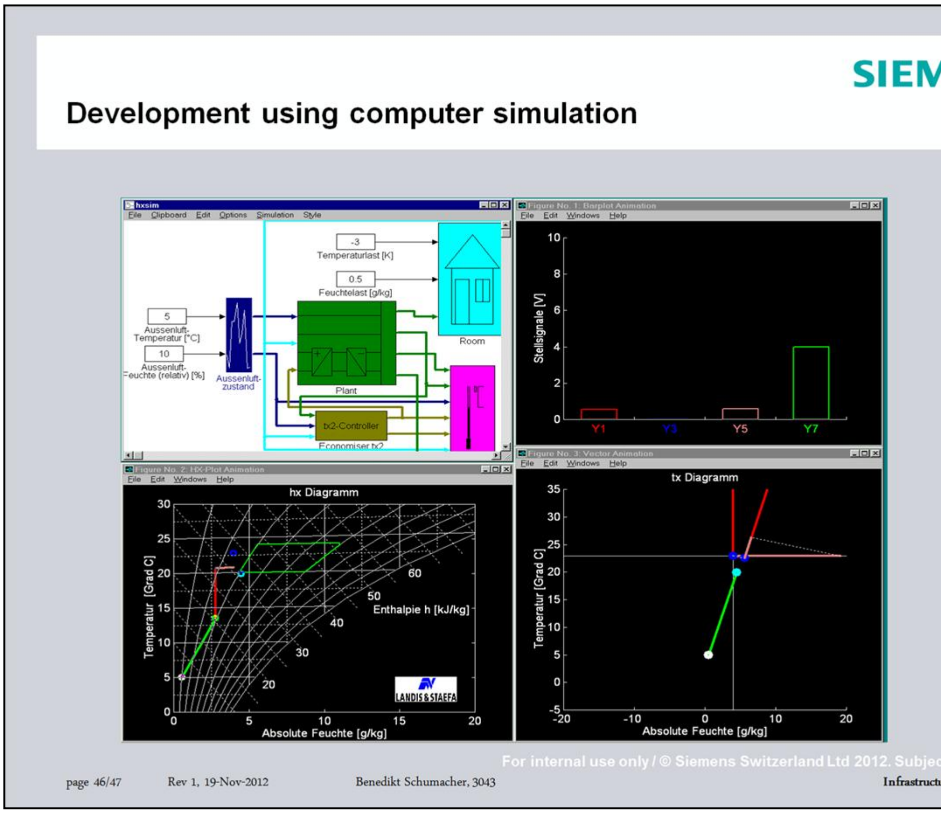
AirOptiControl

- Reference system is the entire plant, i.e. thermal air handling and air transportation
- Ca. 50% overall energy savings (actuator energy and thermal energy), depending on the starting point (comparison of control strategy) and load situation

SIE

Summary

- Minimize energy consumption, costs, or CO2 through optimun control of energy recovery.
  ERC controls outside the control sequences; weighting factors setpoint within the comfort field are optimized dependent on th active process in the air handling unit)
- Modulating process, without the typical hysteresis for ERC co action changeover
- Absolute humidity control, i.e. improved control quality through coupling temperature and humidity
- Control cockpit, i.e. the energy consumption of conventional E control process is calculated against idealized processes as a comparative variable to tx2 and can be displayed in a prepare
- Meets CEN standard for h,x-control
- Available in DESIGO as of version 4.0



Development environment

The simulation package MATLAB/Simulink was used to develop the Economizer tx2 algorithm

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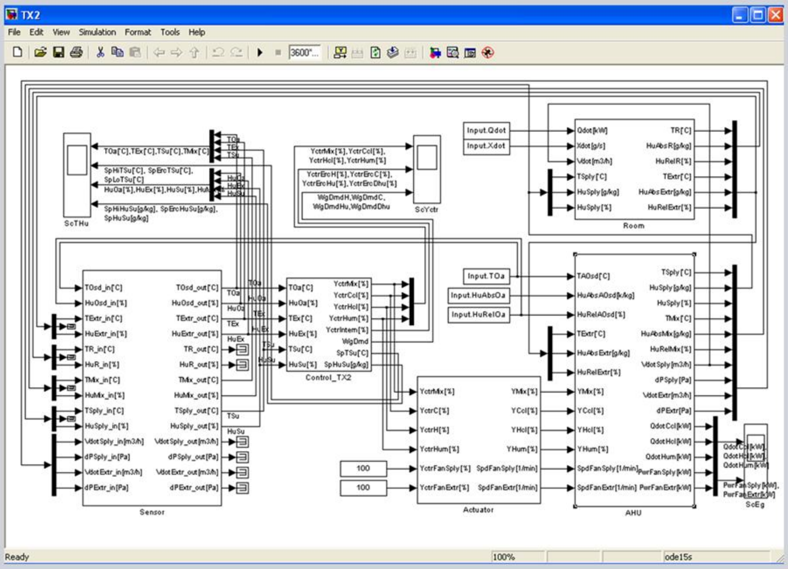
Simulation design for benchmarking tx2, BM, VCS



Simulations on functional certification of the tx2 algorithm, typical example

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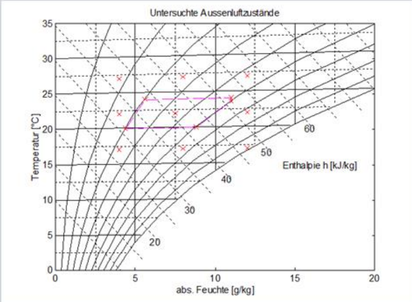
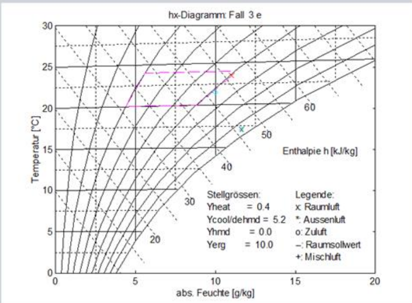
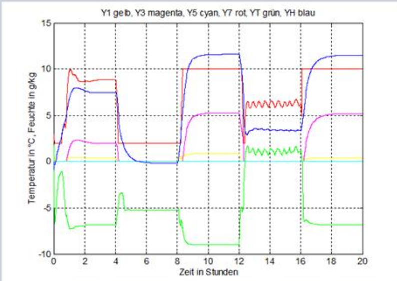


Load case	Temperature load in Kelvin	Hum. load in g/kg
a	0	0
b	-2	-1
c	-2	+1
d	+2	-1
e	+2	+1

Top: Load situations
Outside air states and room load cases

Bottom: Results





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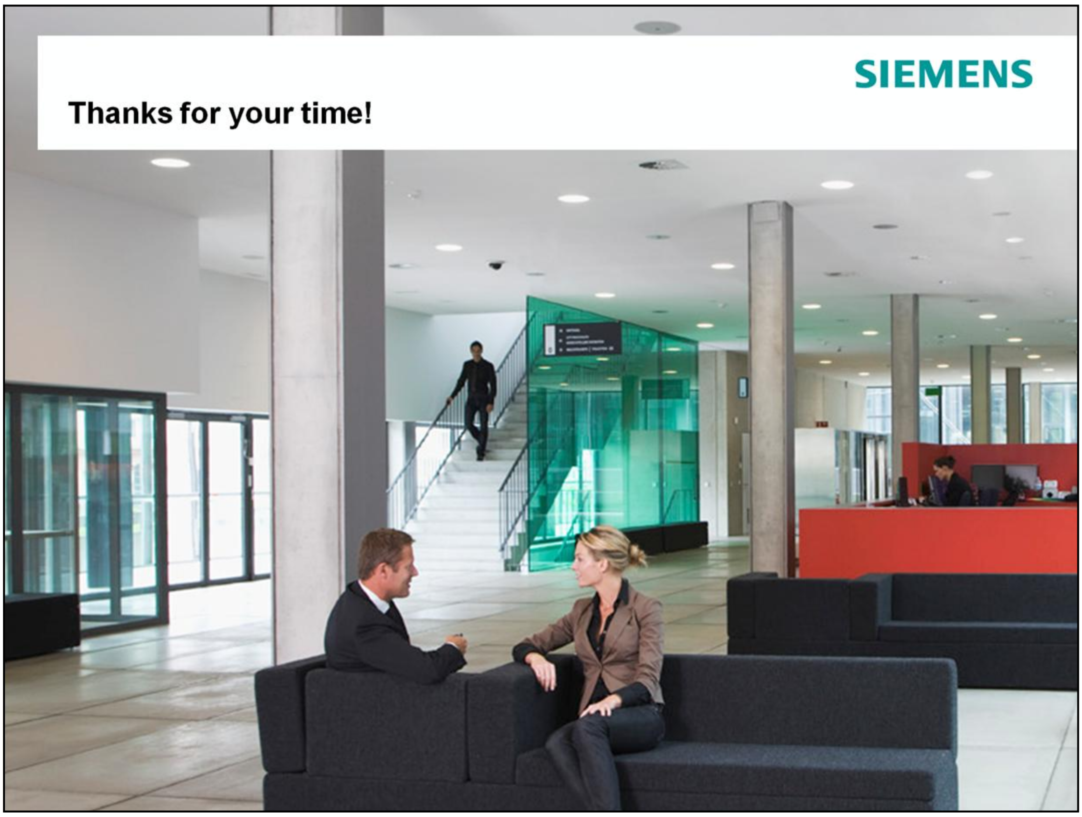
Questions

- Function principle?
- For what plants is it suitable?
- Energy savings potential?
- Where in the hx-diagram is tx2 better?
- How are current setpoints displayed?
- Does it make sense to remodel existing plants (expense/payoff)?
- What does a plant with steam humidification look like (Chemie Basel has available factory steam)?
- Where is tx2 better than a conventional CAS solution with setpoint field and now much better (energy savings in %)?
- tx2 with complete HRC plant?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Thanks for your time!

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TABS-Control

Control of thermally activated building systems (TABS)

DESIGO – Energy efficiency applications

RC-SE, December 2012

Markus Gwerder
Siemens Switzerland Ltd, Zug
Building Technologies Division
Control Products & Systems
markus.gwerder@siemens.com

TABS-Control
Content

SIEMENS

- Introducing TABS control
- The KTI project TABS control
  - Project data and project organization
  - Project results
- The Siemens BT TABS control solution in Desigo
  - Delivery
  - Function
  - Benefits
  - Demo (Matlab/Simulink simulation)
- The Siemens/Empa planning tool TABSDesign
  - Introduction
  - Demo
- Questions and discussion


TABS-Control
Introduction

TABS-Control
Introduction

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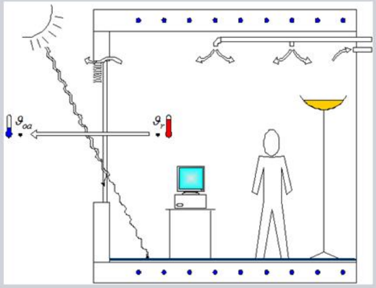
What is thermally activated building system TABS?

TABS register with steel reinforcement



Test room Siemens HVAC Laboratory

TABS-Control
Introduction

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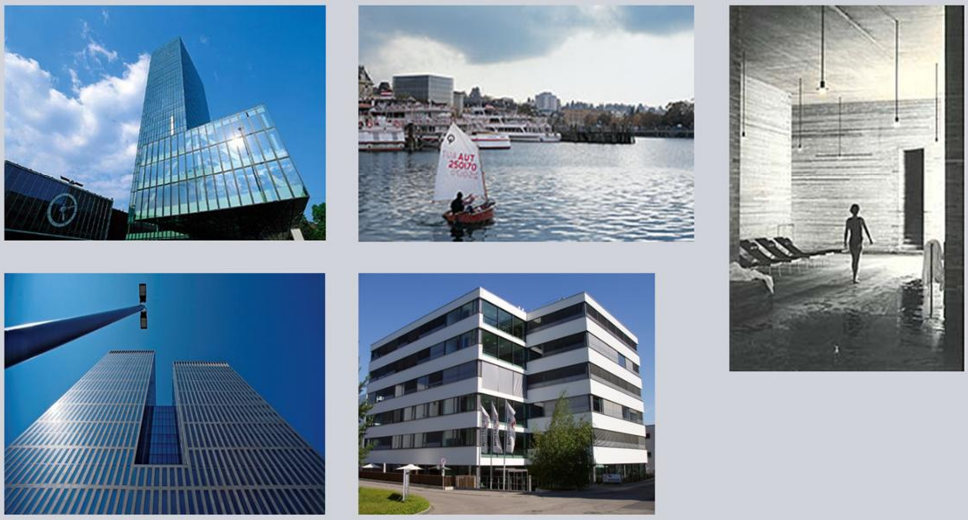
Building with TABS: Some examples



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TABS-Control
Introduction

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TABS benefits

- **Takes advantage of natural sources of energy**
  Low temperature differences between flow and room temperatures
  ⇨ Energy-efficient solutions
- **Self-regulation effect**
  Low temperatures between flow and room temperatures
  ⇨ Simple installation and control-technical solutions (no individual room temperature control)
- **Takes advantage of the large thermal storage medium of TABS**
  Large thermal storage capacity from TABS permits a time-based separation of heat/refrigeration demand and heat/refrigeration distribution
  ⇨ Energy-efficient solutions, e.g. free cooling at night, cycle operation using recirculating pumps

TABS-Control
Introduction

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Difficulties in using TABS

- **Not completely free with ceiling/floor construction**
  high thermal coupling with TABS to the rooms
  ⇨ Conflict with raised floor, lowered ceilings, sound insulation, …
- **Not all demands on thermal comfort possible**
  An increase in room temperature during the day must be tolerated
  ⇨ Conflict with: Restrictive demand on thermal comfort range
- **Challenging HVAC planning**
  Knowledge of building use during HVAC planning. Securing acceptance to the two points above. Integrated planning of HVAC plant and its control (dynamic sizing).
- **Use of conventional control strategies**
  The use of conventional control strategies, especially room temperature control only function at an unsatisfactory level.
  (TABS is very sluggish, difficult changeover from heating to cooling mode)


KTI Project TABS-Control
Data and organization

TABS-Control
Project data and project organization

SIEMENS

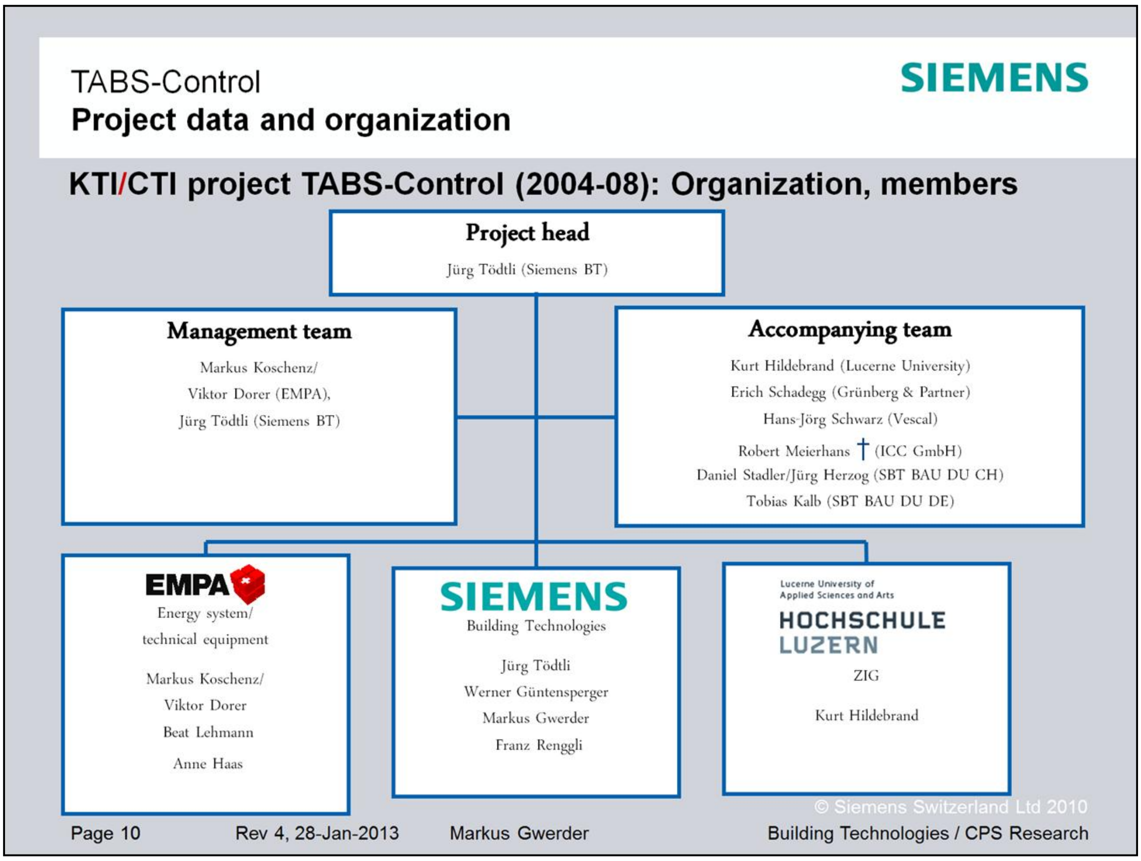
KTI Project number 7046.1 IWS-IW

TABS-Control, control of thermally activated building systems

Project partner
University: Empa Building Technologies; Hochschule Luzern
Business: Siemens Switzerland Ltd, Building Technologies

Project begin: May 1, 2004
Project period: 43 months (until November 30, 2007)

Application amount: CHF 633,400.-
Federal contribution: CHF 316,900.-



ZIG = Zentrum für Integrale Gebäudetechnik


KTI project TABS-
Control
Results

TABS-Control
Project results

SIEMENS

- A selection of **control strategies** for zone control
- Implemented some of these strategies as standard solutions in **Desigo V4**
- Tests were conducted on these strategies in the Siemens **HVAC Lab**
- A new method to integrate **TABS planning** and its control
- Software planning tool TABSDesign
- **Simulation programs** and performance-bound calculations
- Guidelines on selecting topology of **hydraulic switching**
- A method for **setting** control during the initial operating phase
- A theory to control TABS (“UBB method”)
- **Manual** on controlling TABS
- Various other publications and patent registration

TABS-Control
Project results

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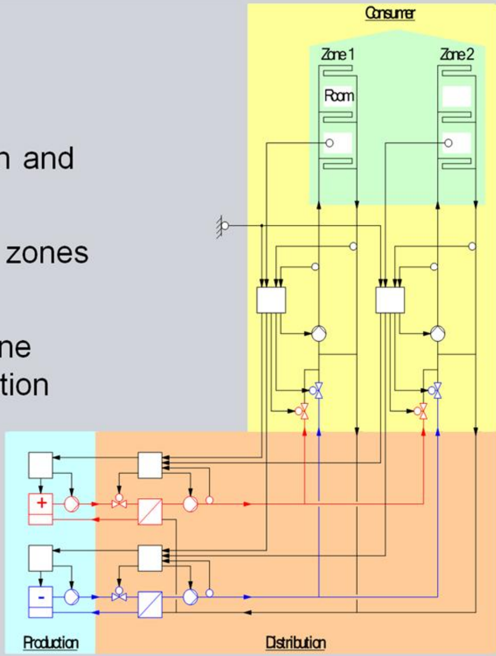
TABS plant with control

- Separation in consumer, distribution and production of heat and cold
- Separation of consumer (rooms) in zones (typically 2-3 zones per building)
- Separation of the control task in zone control, control of heat/cold distribution and control of heat/cold production



TABS-Control
Project results

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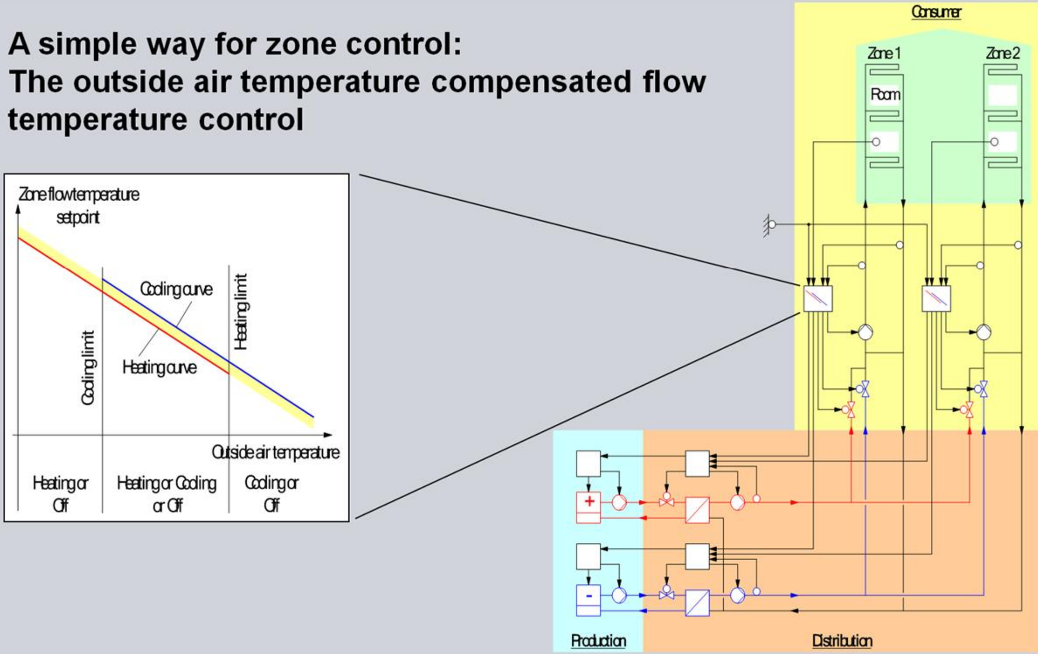
A simple way for zone control: The outside air temperature compensated flow temperature control



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TABS-Control

Project results

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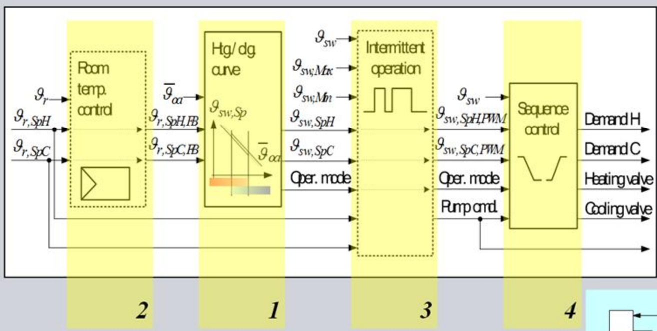
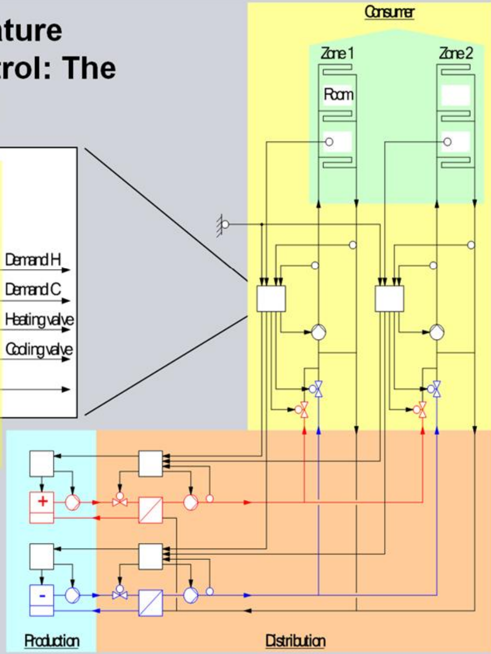
Extension of the outside air temperature compensated flow temperature control: The modular TABS-Control zone control





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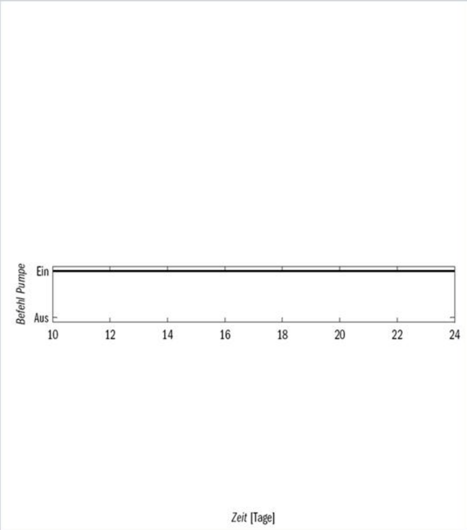
TABS-Control
Project results

Simulation example of TABS-Control zone control strategy

Continuous operation



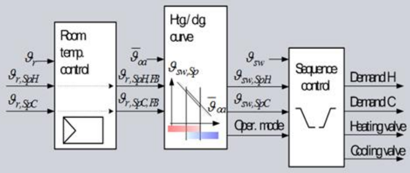
Room temperature and
room temperature setpoint range

Flow temperature, return temperature
and flow temperature setpoint range

Pump command

Outside air
temperature

Heat
gains



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TABS-Control
Projektresultate

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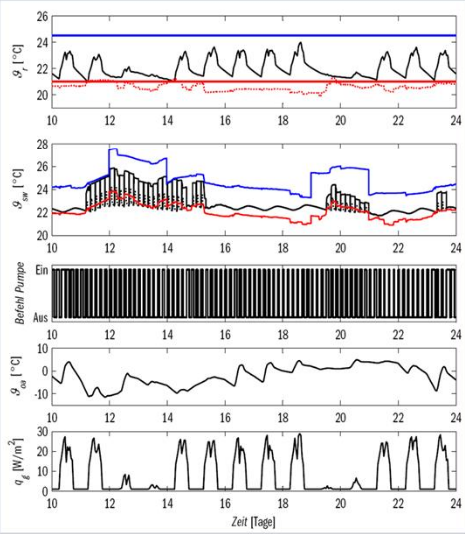
Simulation example of TABS-Control zone control strategy

Intermittent operation



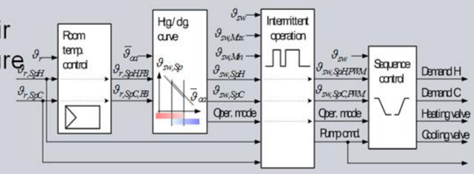
Room temperature and room temperature setpoint range

Flow temperature, return temperature and flow temperature setpoint range

Pump command

Outside air temperature

Heat gains



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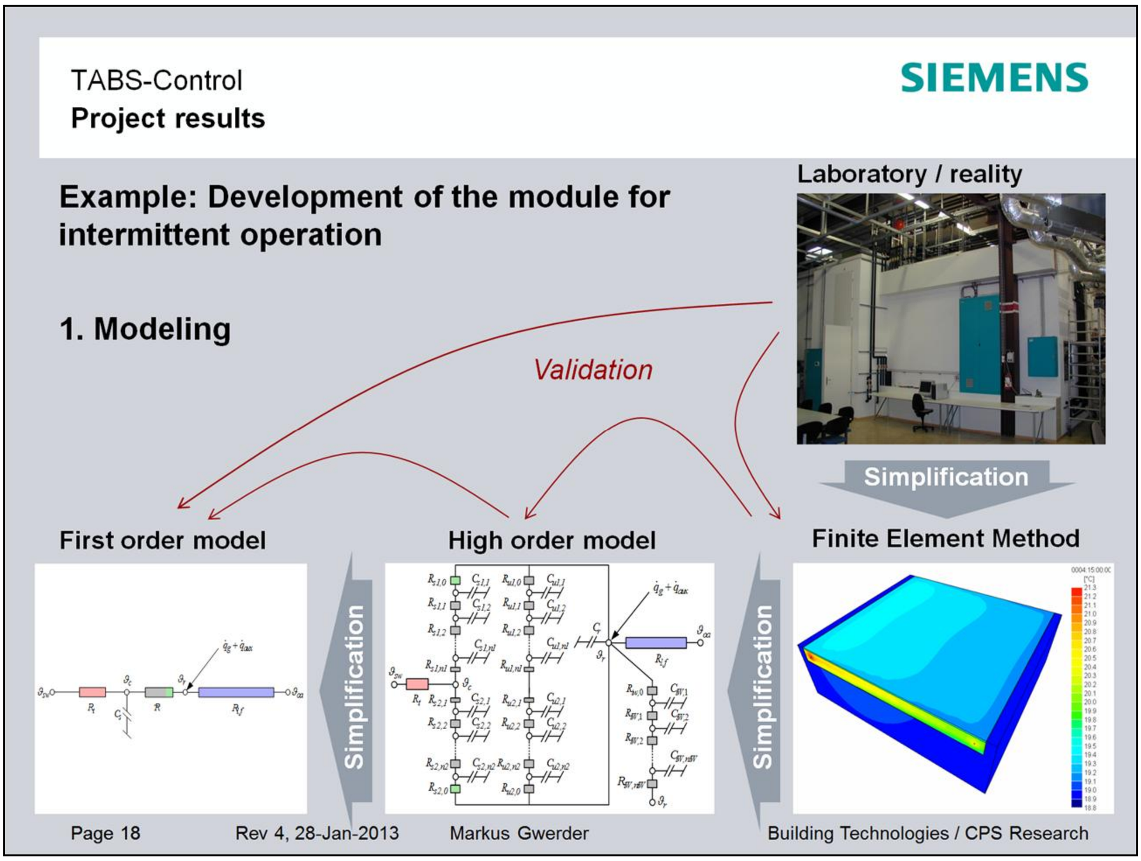
TABS-Control
Project results
SIEMENS
Example: Development of the module for intermittent operation
1. Modeling
Laboratory / reality
Validation
Simplification
First order model
High order model
Finite Element Method
Simplification
Simplification
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TABS-Control
Project results

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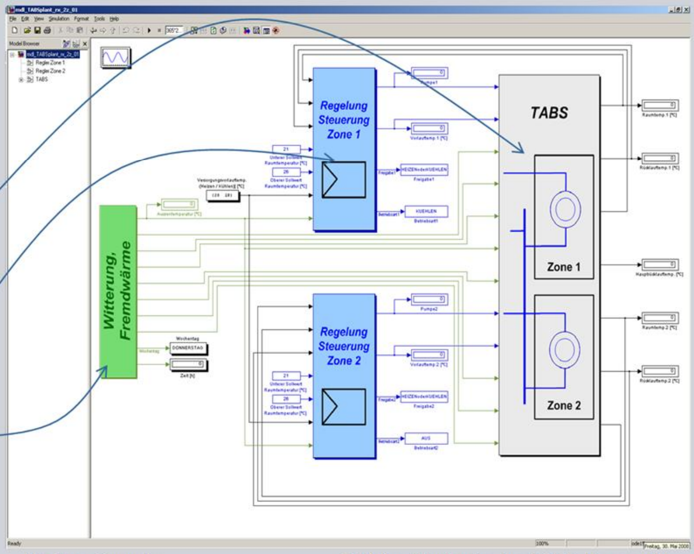
Example: Development of the module for intermittent operation

2. Design / simulation



High order model

Control incl.
pulse width modulation
based on first order model

Weather data (measurements),
internal heat gains

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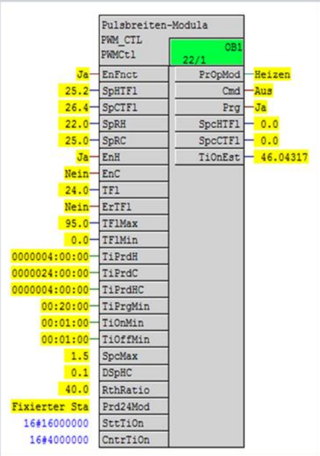
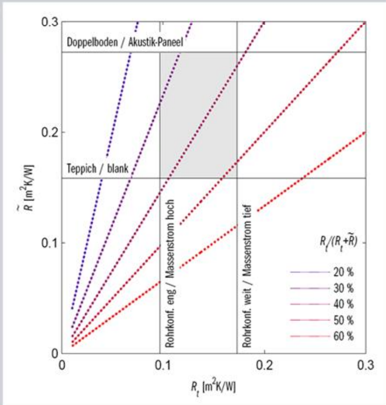
TABS-Control
Project results

Example: Development of the module for intermittent operation

3. Implementation / definition HMI



Parameter	Value (example)
Period of heating PWM operation	4 h
Period of cooling PWM operation	24 h
Period of unknown PWM operation	4 h
Maximum correction of flow temperature setpoint	1.5 K
Minimal purge operation time	20 min
Minimal pump switch-on time	1 min
Minimal pump switch-off time	1 min
PWM thermal resistance ratio	40 %



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TABS-Control
Project results

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Example: Development of the module for intermittent operation

4. Tests in laboratory

TABS-Control
Project results

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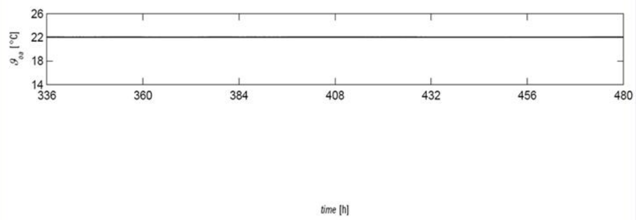
Example: Development of the module for intermittent operation

4. Test in laboratory: Cooling in 24 hours PWM operation



Room temperature and
room temperature setpoint range

Flow temperature, return temperature
and flow temperature setpoint range

Pump command

Purge operation

Temperature in weather zone

Heat gains

TABS-Control
Project results

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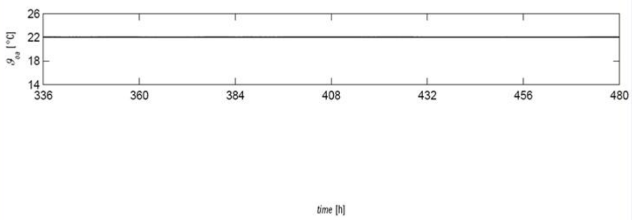
Lab test: Cooling in 24-hour cycle operation



Room temperature and
Room temperature setpoint range

Flow temperature, return temperature and flow temperature setpoint

Pump command

Purge mode (neutral mode)

Temperature weather zone

Heat gains

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TABS-Control
Project results

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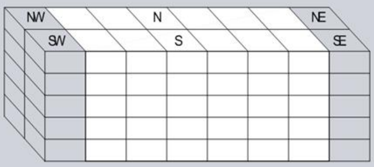
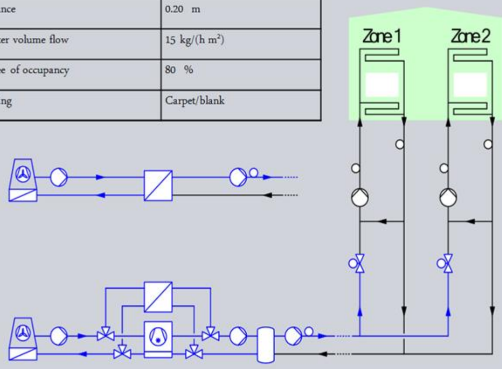
Case Study on energy demand and energy efficiency

Building data	
Location	Zurich
Dimensions of individual room L x W x H	6 m x 6 m x 3 m
Average U-value of the Façade	0.65 W/(m² K)
Glass portion Normal offices Corner offices	 21 % 42 %
Solar heat penetration Window (g value) Window and blinds	 0.41 - 0.08 -

TABS configuration	
Cement ceiling thickness	0.25 m
Piping distance	0.20 m
Specific water volume flow	15 kg/(h m²)
TABS degree of occupancy	80 %
Floor/ceiling building	Carpet/blank



Building configuration with orientation and zone distribution



Plant diagram refrigeration generation:
Variant cooling tower monovalent (top)
Variant refrigeration machine including free cooling switching

TABS-Control
Project results

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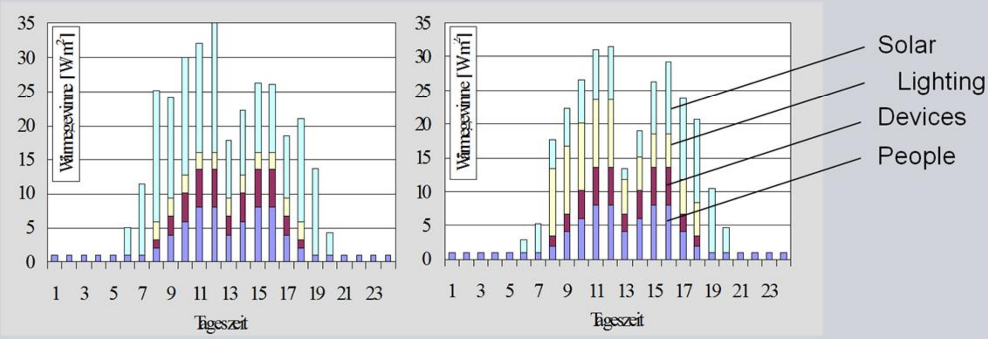
Case Study on energy demand and energy efficiency

Upper heat gain barriers for work days

Corner offices — Normal office



TABS-Control
Project results

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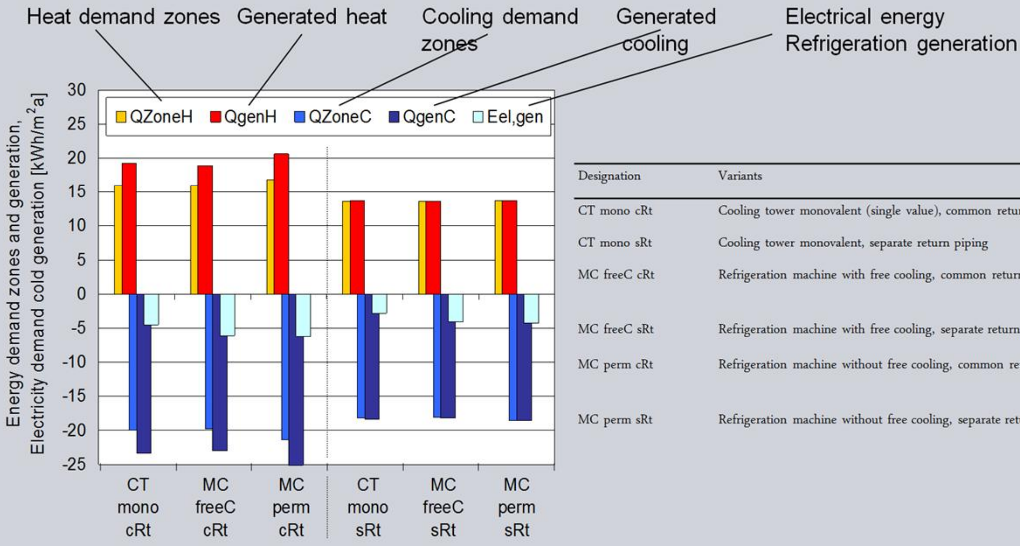
Case Study on energy demand and energy efficiency



Designation	Variants
CT mono cRt	Cooling tower monovalent (single value), common return piping
CT mono sRt	Cooling tower monovalent, separate return piping
MC freeC cRt	Refrigeration machine with free cooling, common return piping
MC freeC sRt	Refrigeration machine with free cooling, separate return piping
MC perm cRt	Refrigeration machine without free cooling, common return piping
MC perm sRt	Refrigeration machine without free cooling, separate return piping

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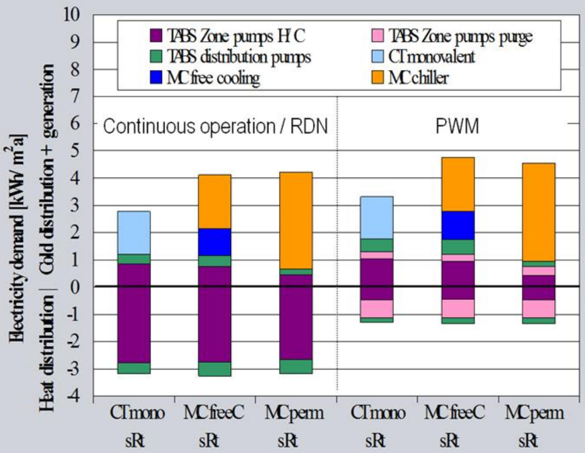
TABS-Control
Project results

Case Study on energy demand and energy efficiency

Continuous operation / RDN: Continuous heating mode, cooling mode at night (using return temperature criterion)

PWM: Heating and cooling mode in cycles (with flow temperature criterion)



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TABS-Control
Project results

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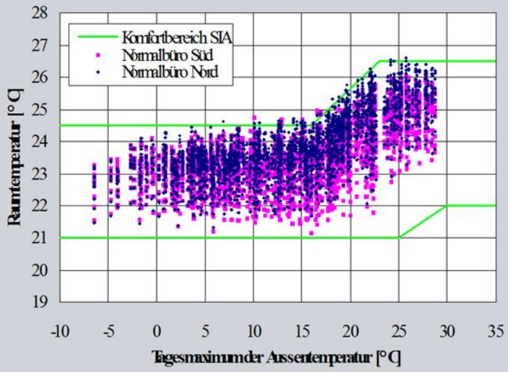
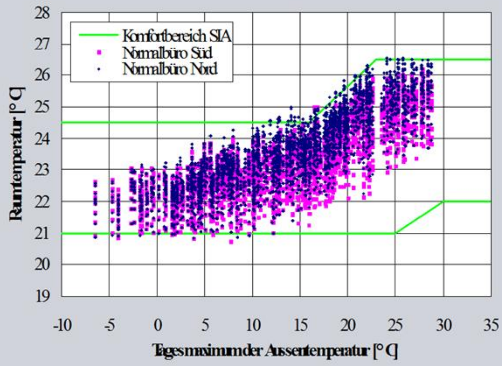
Case Study on energy demand and energy efficiency

Comfort dependent on the hydraulic topology

Common return piping



Separate return piping



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TABS-Control

Project results

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Lab tests

TABS test room at the Siemens HVAC Laboratory

TABS-Control
Project results

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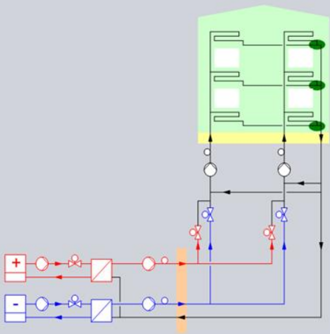
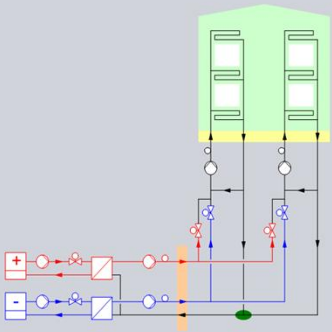
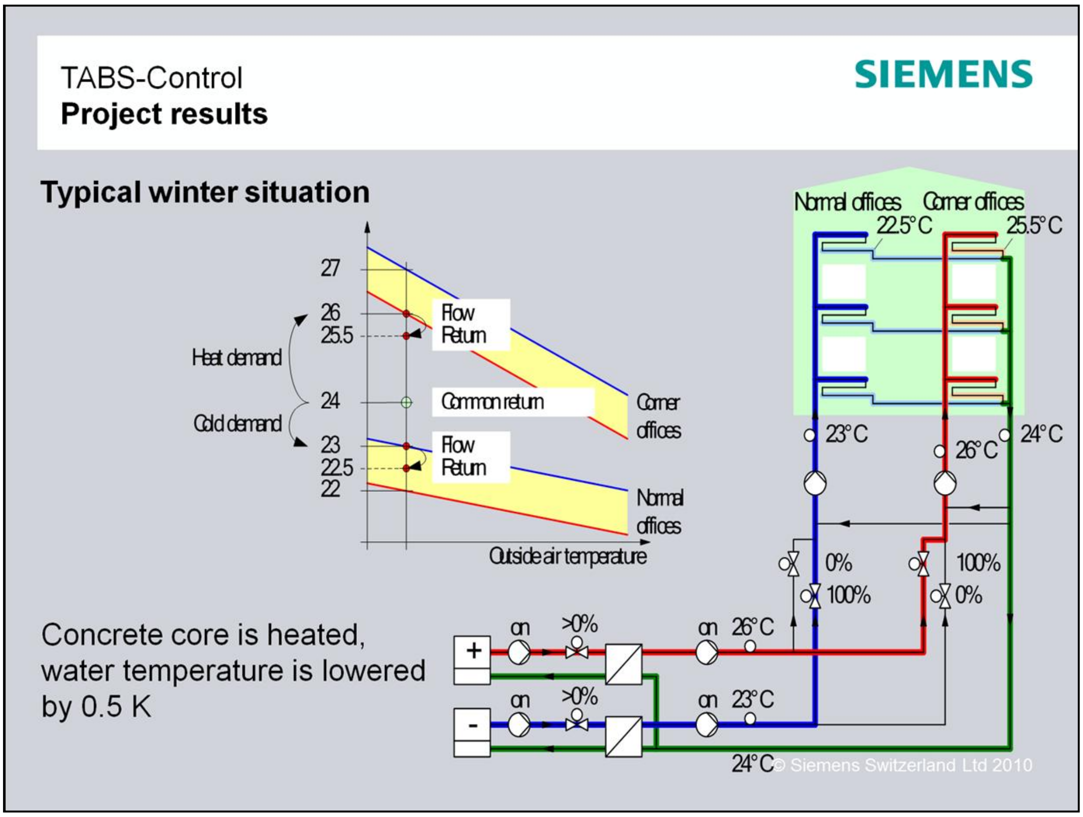
Guidelines on selecting the topology for hydraulic switching
The two most common hydraulic topologies



Three distribution lines with **common** zone return piping



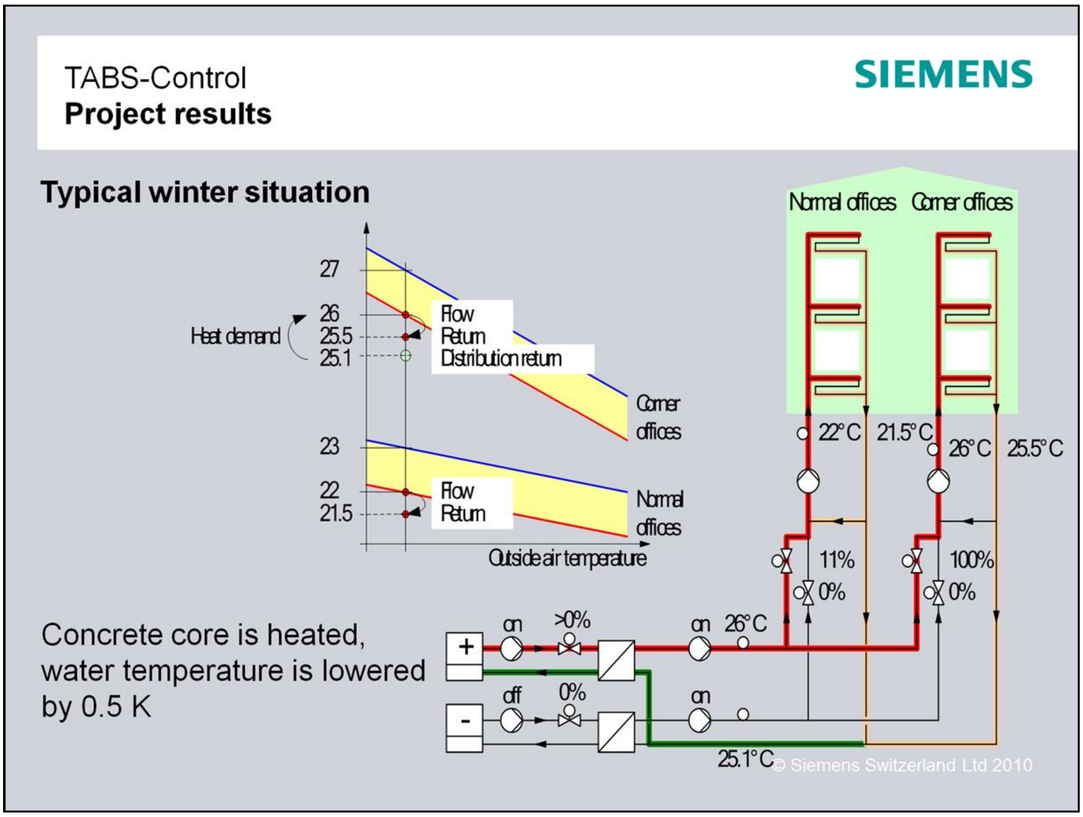
Three distribution lines with **separate** zone return piping



Similar situation for the other topology:

Winter situation, both zones are heated. No cooling. Why? – Because the zone returns are not mixed.

Of course, here we have less energy consumption!



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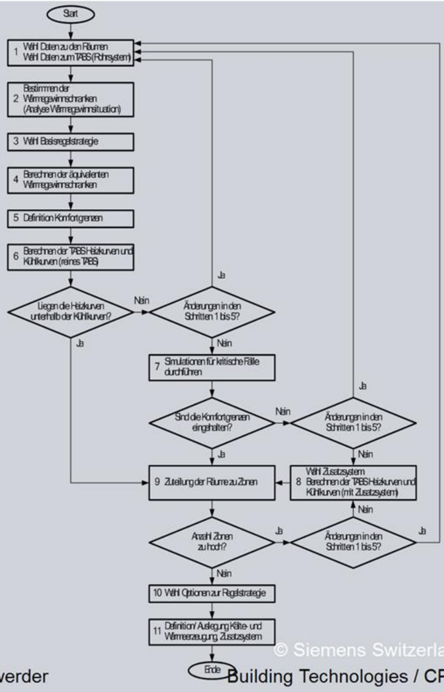
TABS-Control
Project results

SIEMENS

A new method to integrate TABS planning and its control

Planning workflow:

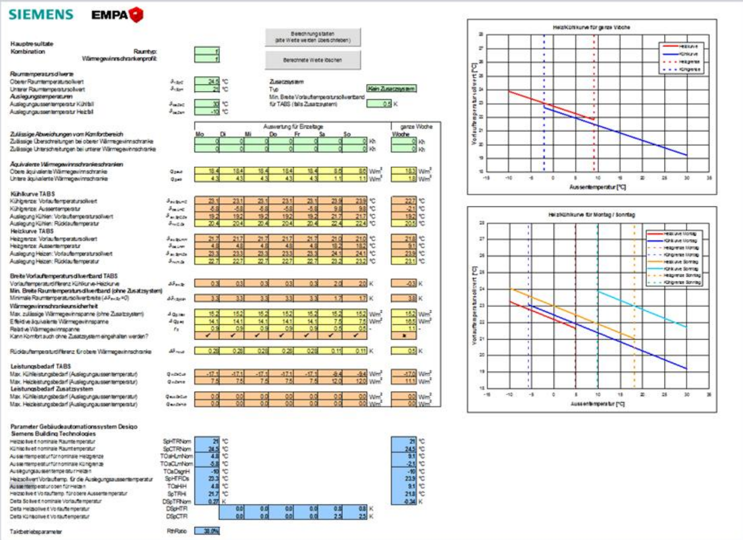


The new planning method allows the planning to plan for TABS and its control for a given building at little expense and high level of drafting a solid solution!

TABS-Control
Project results

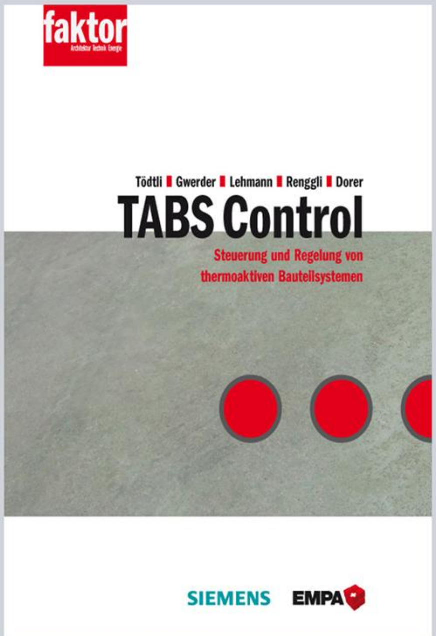
Planning tool TABSDesign (Windows XP)

Download at: www.faktor.ch/?page=tabs



TABS-Control
Project results

SIEMENS



Manual TABS Control - Steuerung und Regelung von TABS (published in March 2009)

May be ordered from the Faktor publishing house: www.faktor.ch

Additional publications (selection)

- "Control of Thermally Activated Building Systems", CLIMA 2007 Helsinki
- "Integrated Design of Thermally Activated Building Systems And of Their Control", CLIMA 2007 Helsinki
- "Effect of the Hydraulic Piping Topology on Energy Demand and Comfort in Buildings with TABS", CLIMA 2007 Helsinki
- "Control of Thermally Activated Building Systems", Applied Energy 2008
- "Control of Thermally Activated Building Systems in intermittent operation with pulse width modulation", Applied Energy 2009


Die Siemens BT
TABS-Control solution in
Desigo

TABS-Control
Desigo

SIEMENS

Implement the solution as of Desigo V4:
Desigo PXC (automation stations), Desigo Insight (management station)

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AP1: Basics

AP1.1 Preparing a simulation tool (including lab trials to validate the model)

AP1.2 Evaluate existing simulation tools

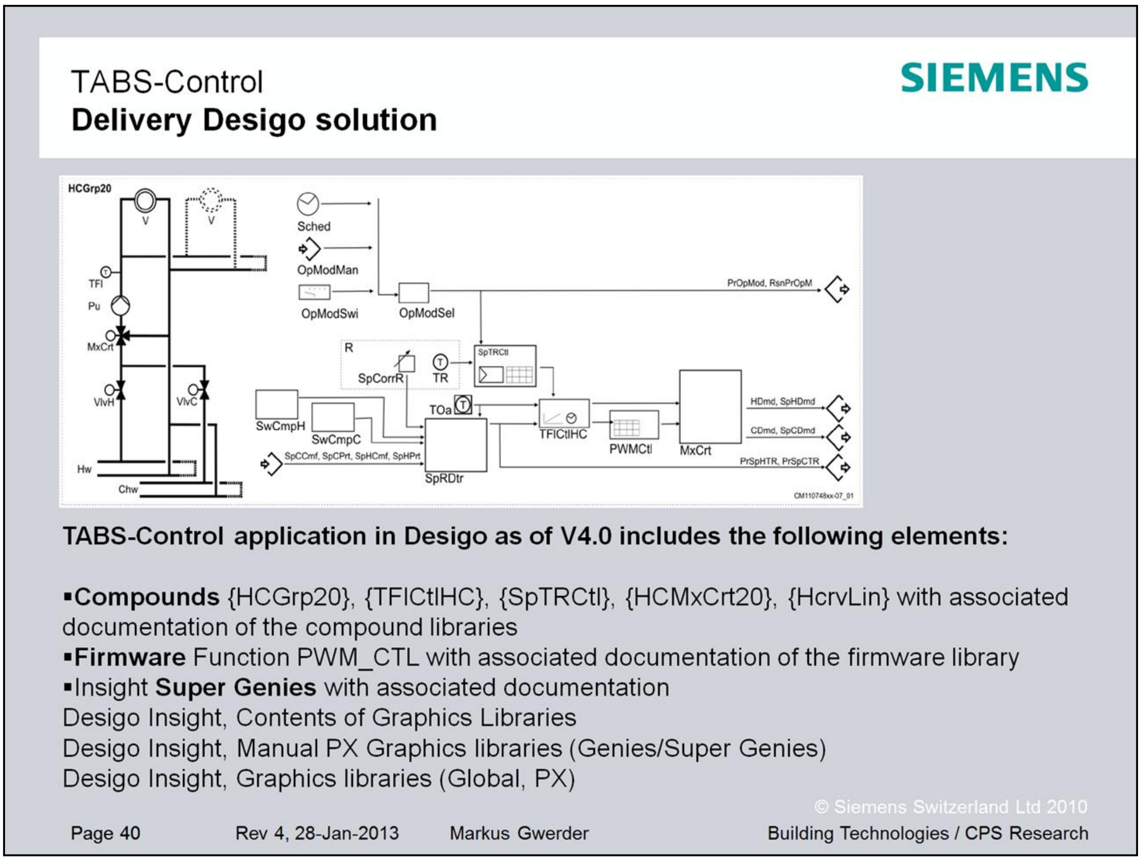
AP1.3 Interaction of TABS with ventilation plants and supplemental systems (deleted)

AP1.4 Examinations on cycle mode

No planned at the start of the project, but quickly concluded:

AP1.x Studies on proceeding in AP2

Various solution approaches developed. Ultimately decided in favor of the solution concept, “Unknown-but-bounded approach”.



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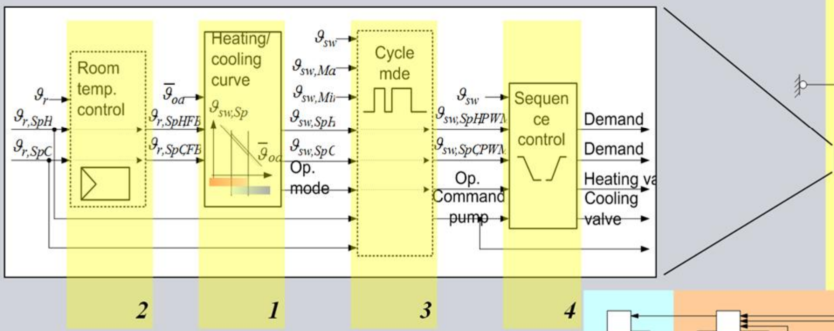
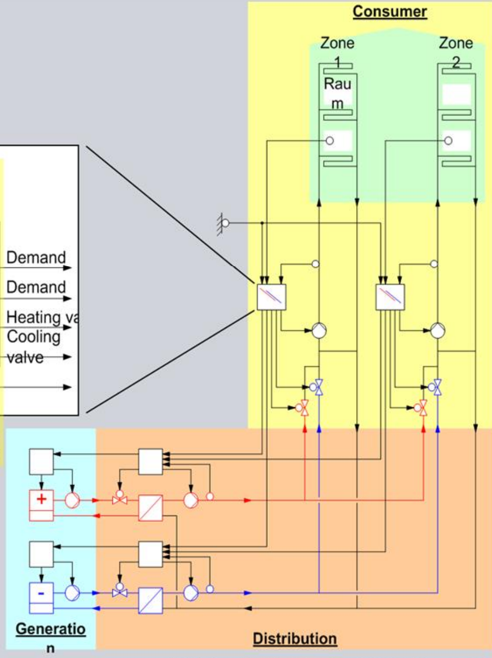
TABS-Control
Desigo

SIEMENS

A new modular TABS zone control





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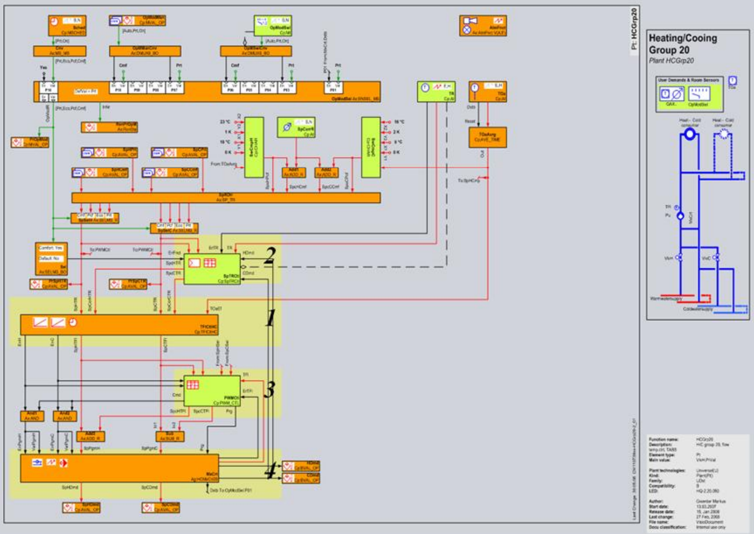
TABS-Control
Desigo

SIEMENS

Implementation of the new solution in Desigo V4: Library element “Plant HCGrp20”



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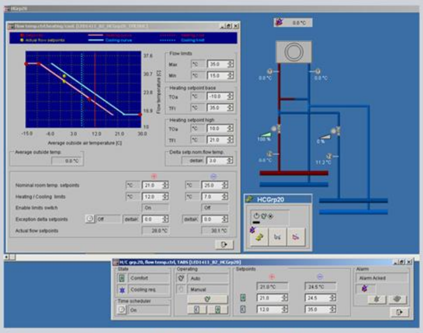
DESIGO – Application example (TABS)
An application for green buildings

SIEMENS

Innovative unique product to reduce energy consumption with the following benefits:

- Control strategy as an integrated component for a TABS building
- Simple and easy-to-understand control strategy
- User-friendly operation
- Year round fully automated operation
- Meets comfort requirements
- Low energy demand (e.g. PWM operation)
- Efficient engineering and commissioning



Visualization in DESIGO INSIGHT

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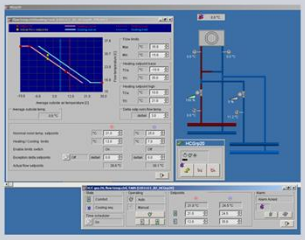
DESIGO – Application example (TABS)

An application for green buildings

SIEMENS

Main benefits

- Lower costs through energy savings
- High protection for your investment thanks to standardized, European-wide energy classes
- The amortization period is shortened thanks to low engineering and commissioning effort
- Reduced maintenance services lower operating costs
- Demonstrates the innovative strength of participating companies



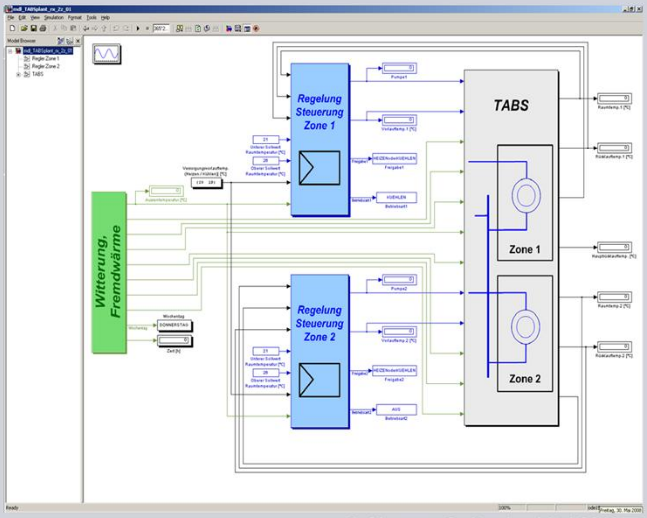
TABS-Control
Desigo

SIEMENS

Implementation of the new solution in Desigo V4: Library element “Plant HCGrp20”

Demo

Matlab/Simulink simulation

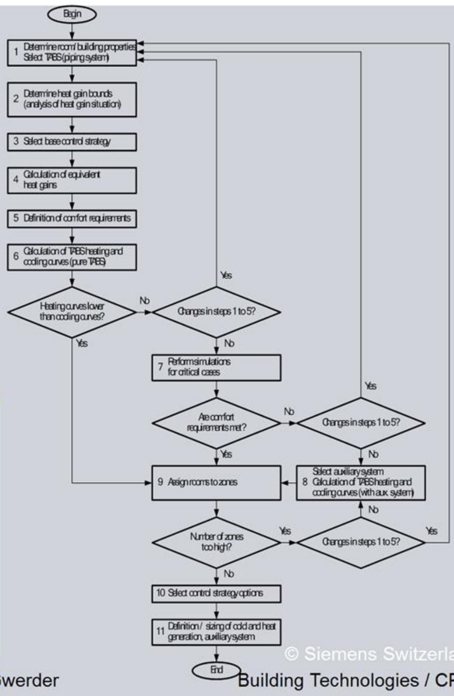



The Siemens/Empa
planning tool
TABSDesign

TABS-Control
Design method

A new method for the integrated design of TABS and their control

Flow chart for the design:



The new design method allows the HVAC designer to design a TABS building with low effort and high design certainty!

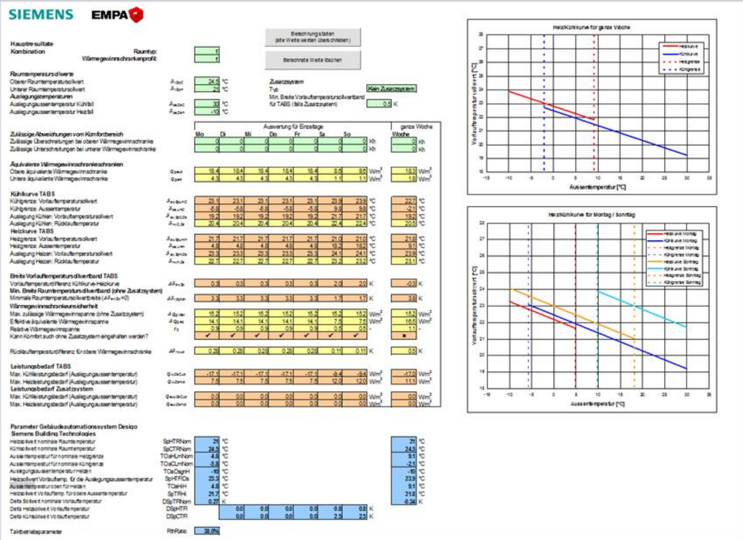
TABS-Control

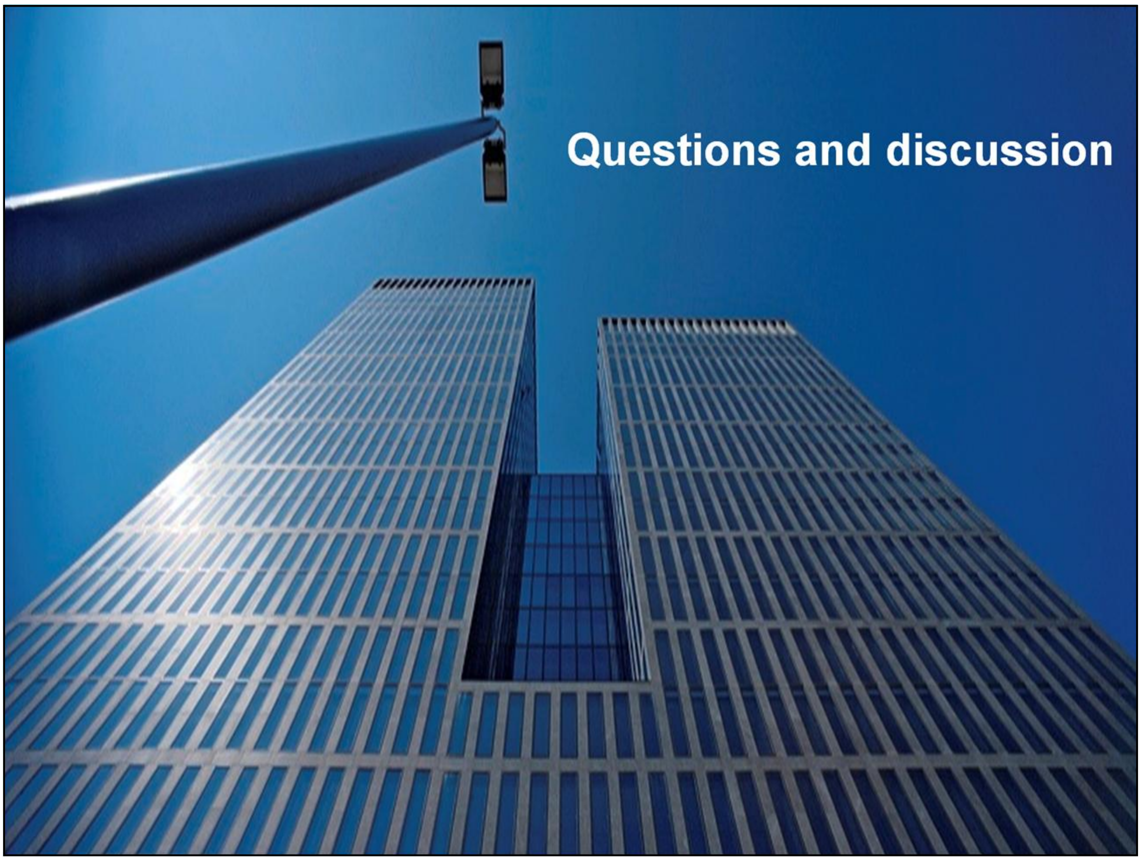
Design method

SIEMENS

Design tool TABSDesign

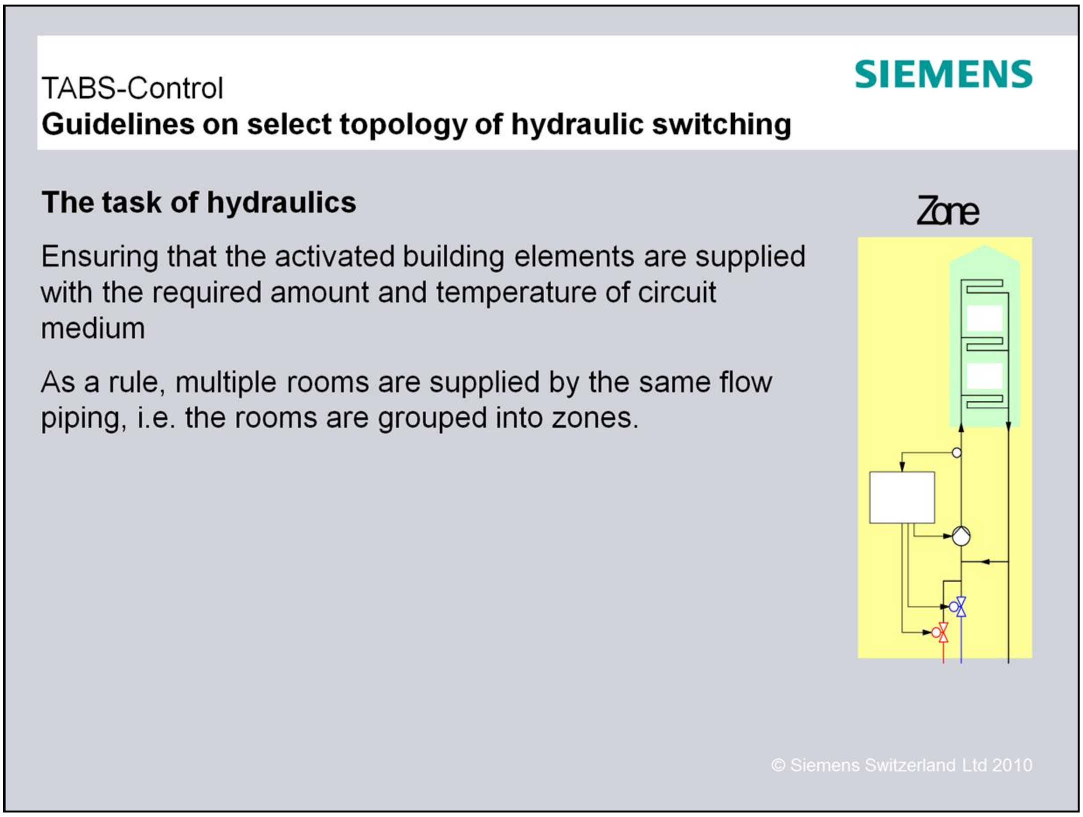
Download: www.faktor.ch/?page=tabs




Questions and discussion


Backup


Guidelines on selecting the topology of hydraulic switching



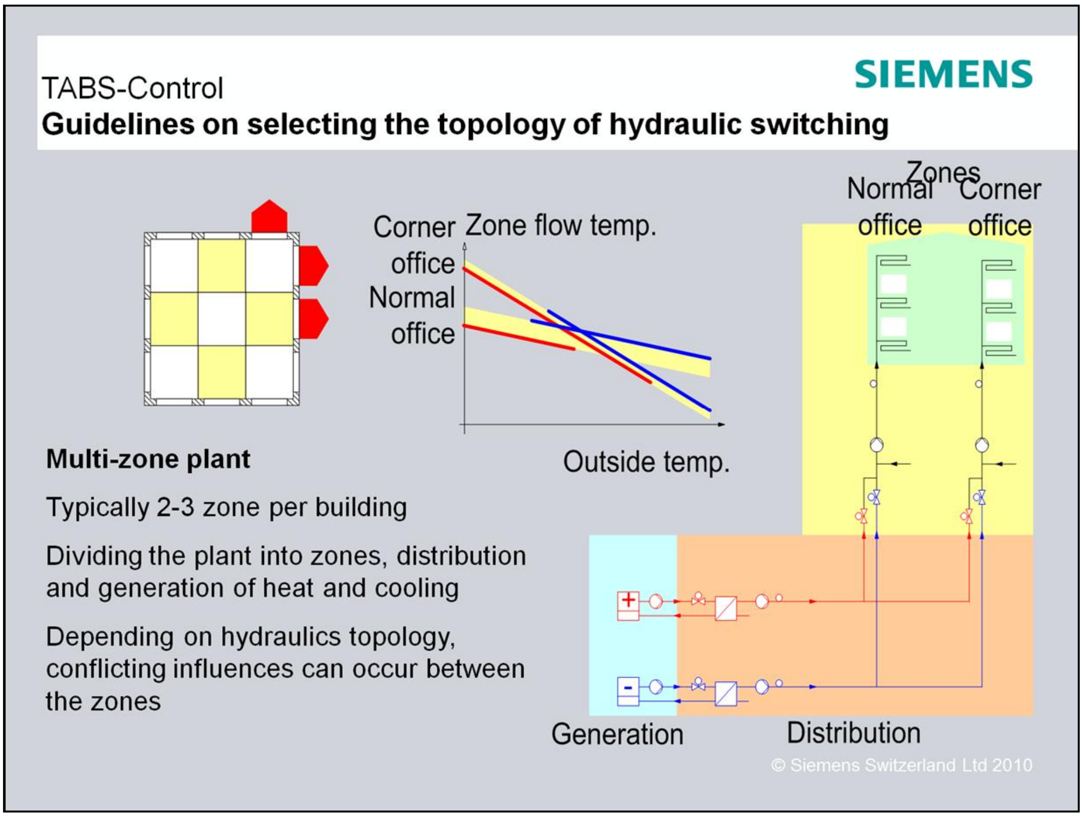
In the paper, we focus on two different hydraulic piping topologies. All the examples are given with two zones (usually no more than 3 zones are defined in buildings).

Common zone return pipe topology: is simple and inexpensive

Separate zone return pipes topology: is a bit more complex and expensive

Both topologies allow each zone to decide about heating or cooling needs.

Only separate zone return topology allows a simultaneous idle operation mode in all zones.



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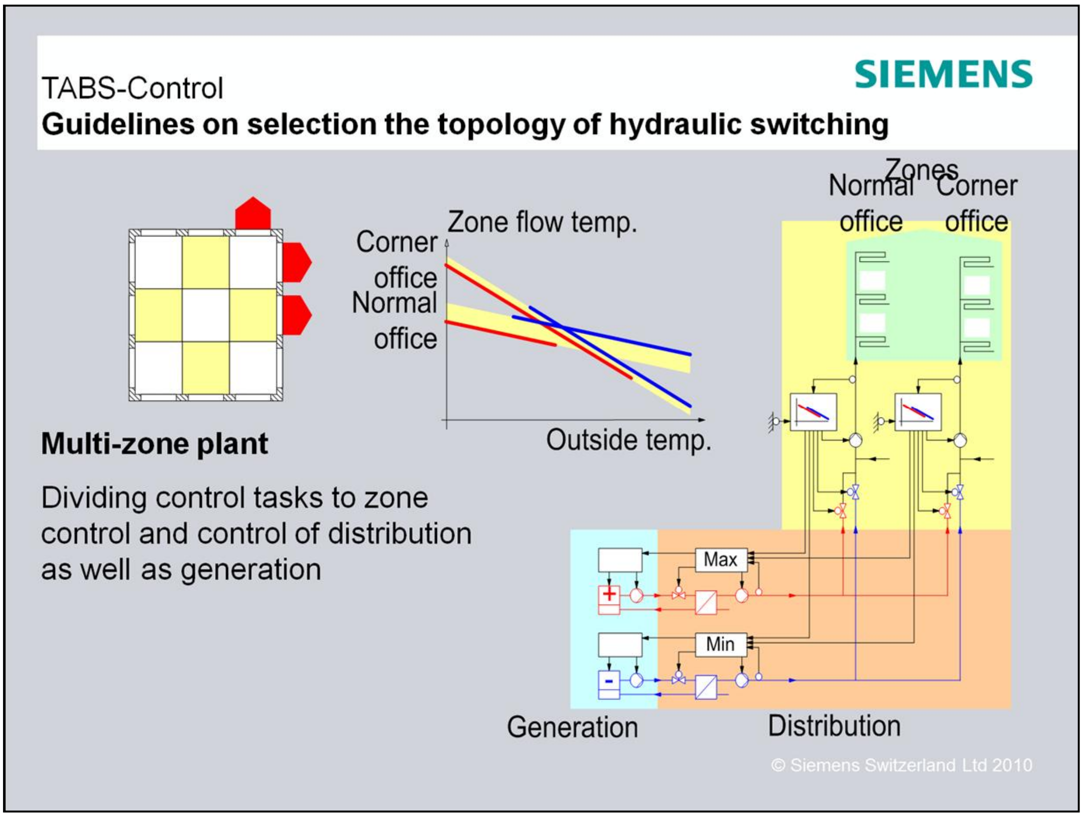

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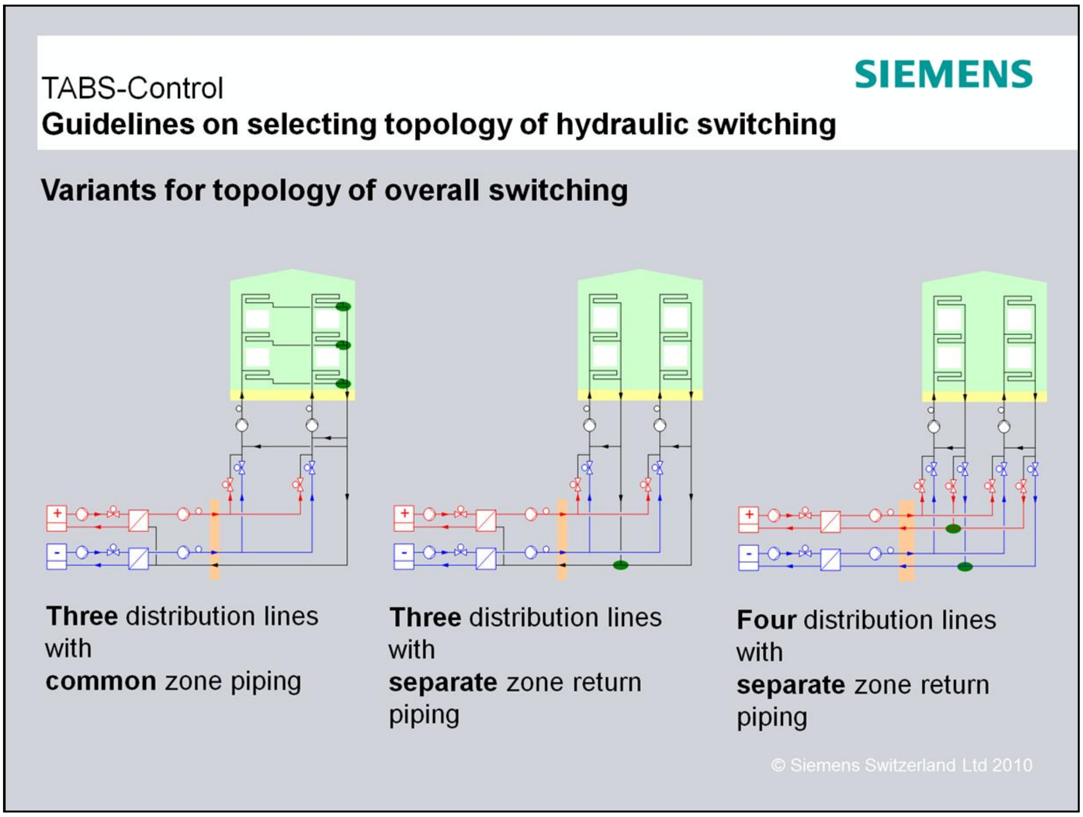

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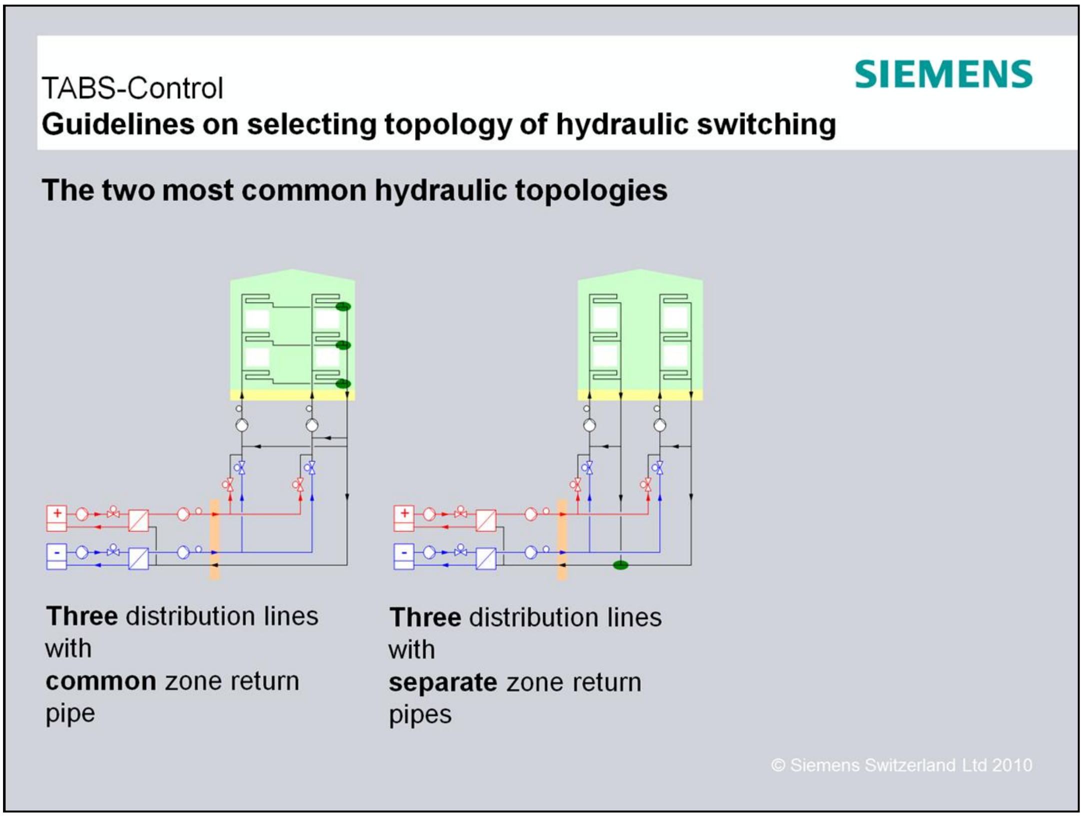

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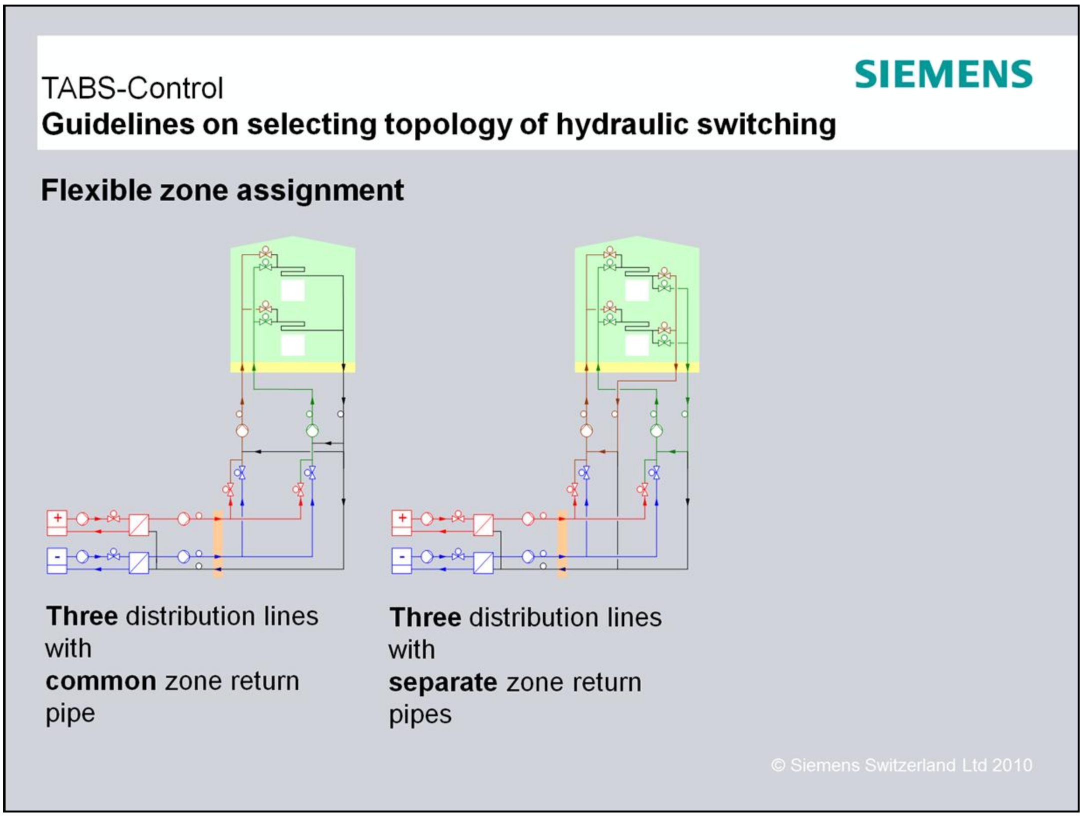

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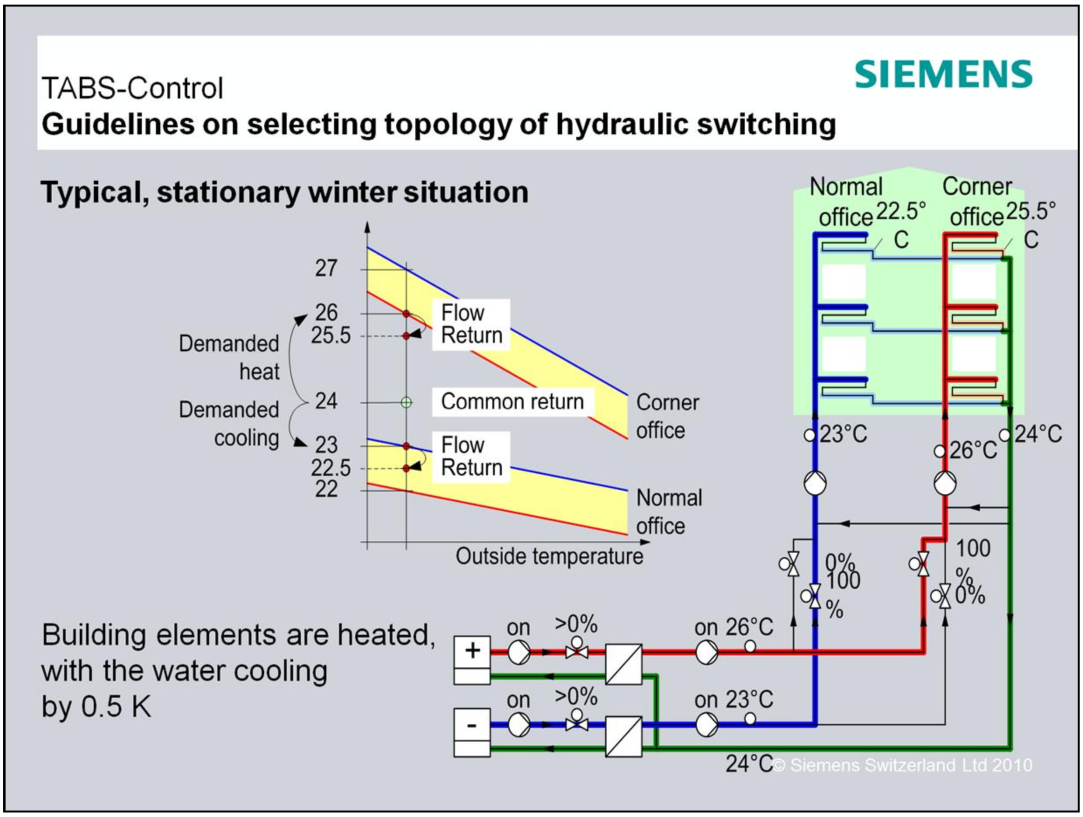

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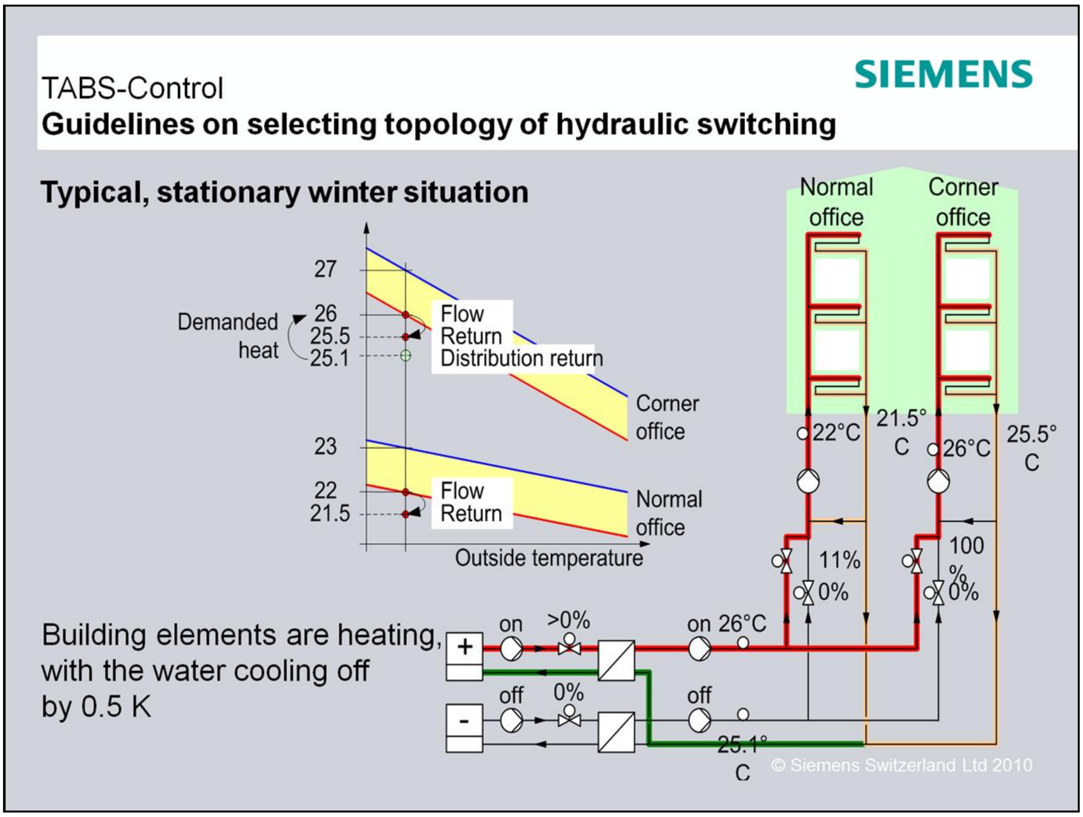

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TABS-Control

Guidelines on selecting topology of hydraulic switching

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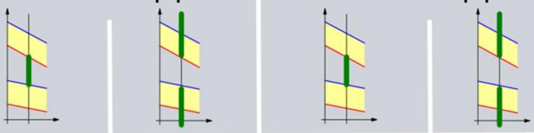
Stationary load situations: Mixing gains and losses



Building elements		Common zone return pipe		Separate zone return pipes	
Normal office Corner office	Heated Heated	Losses	Neutral	Neutral	Neutral
Normal office Corner office	Cooled Heated	Losses	Gains	Losses/ gains	Gains
Normal office Corner office	- -	Losses	Neutral	Neutral	Neutral
Normal office Corner office	Heated Cooled	Losses	Gains	Gains	Gains
Normal office Corner office	Cooled Cooled	Losses	Neutral	Neutral	Neutral

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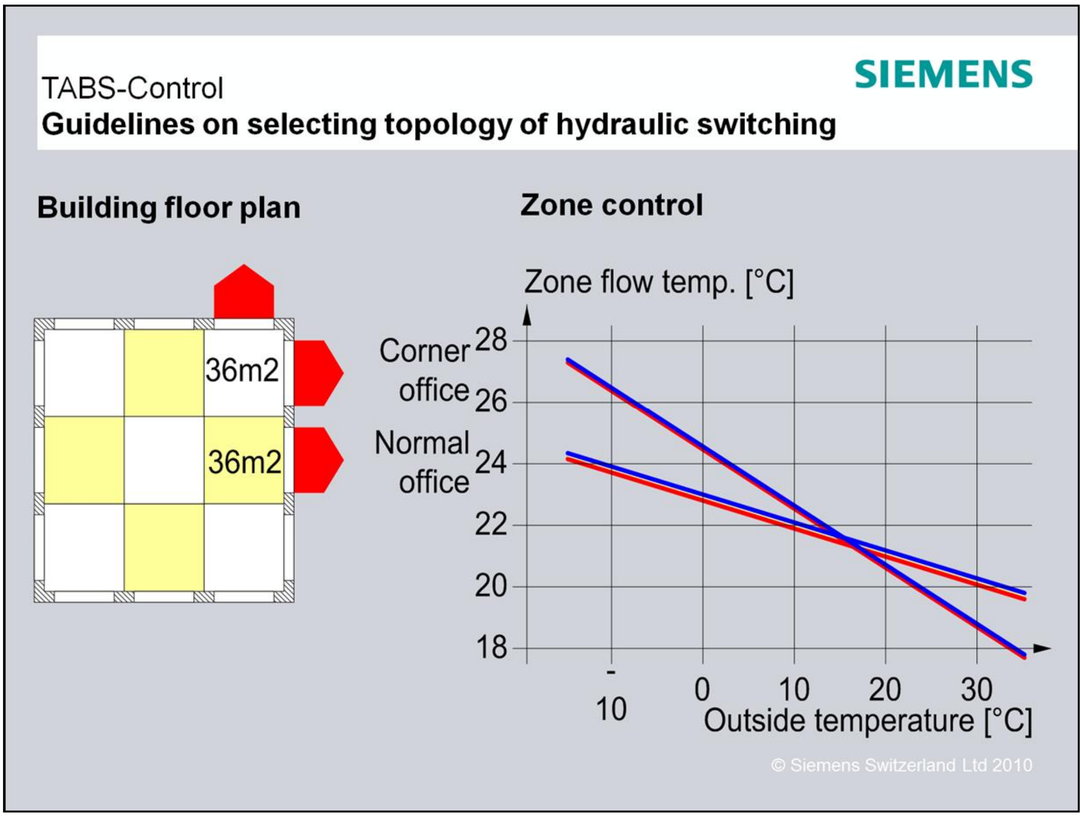

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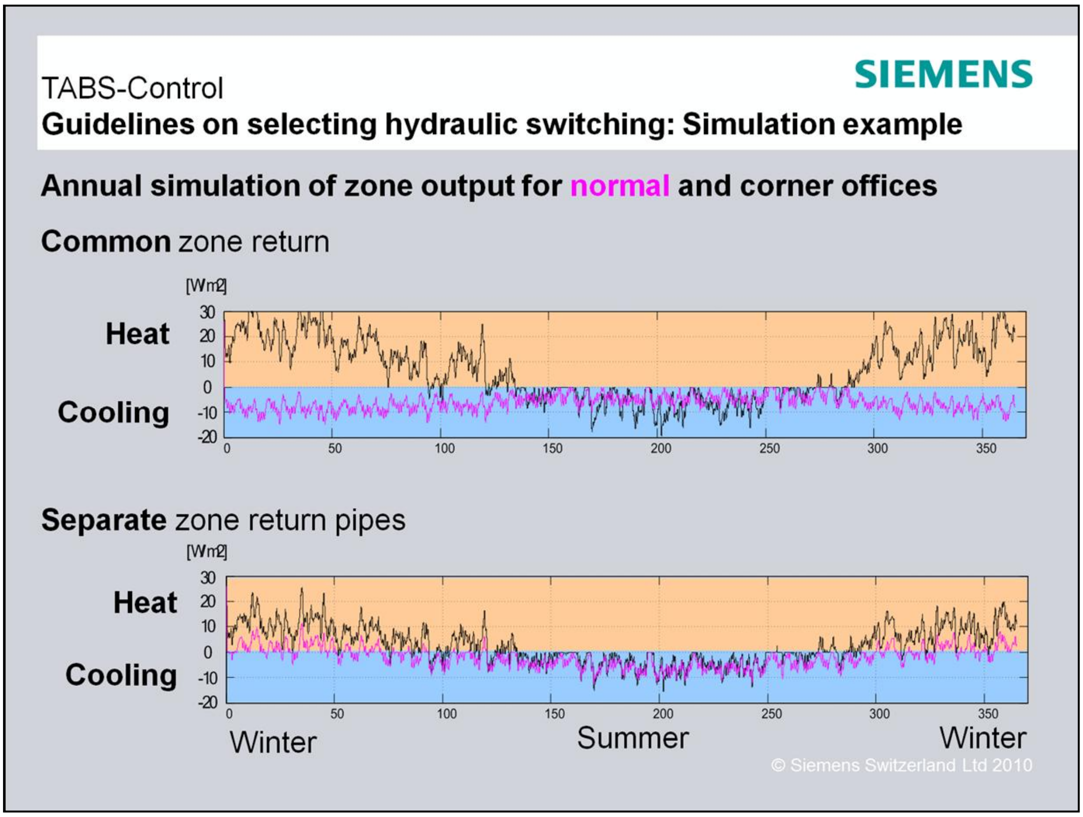

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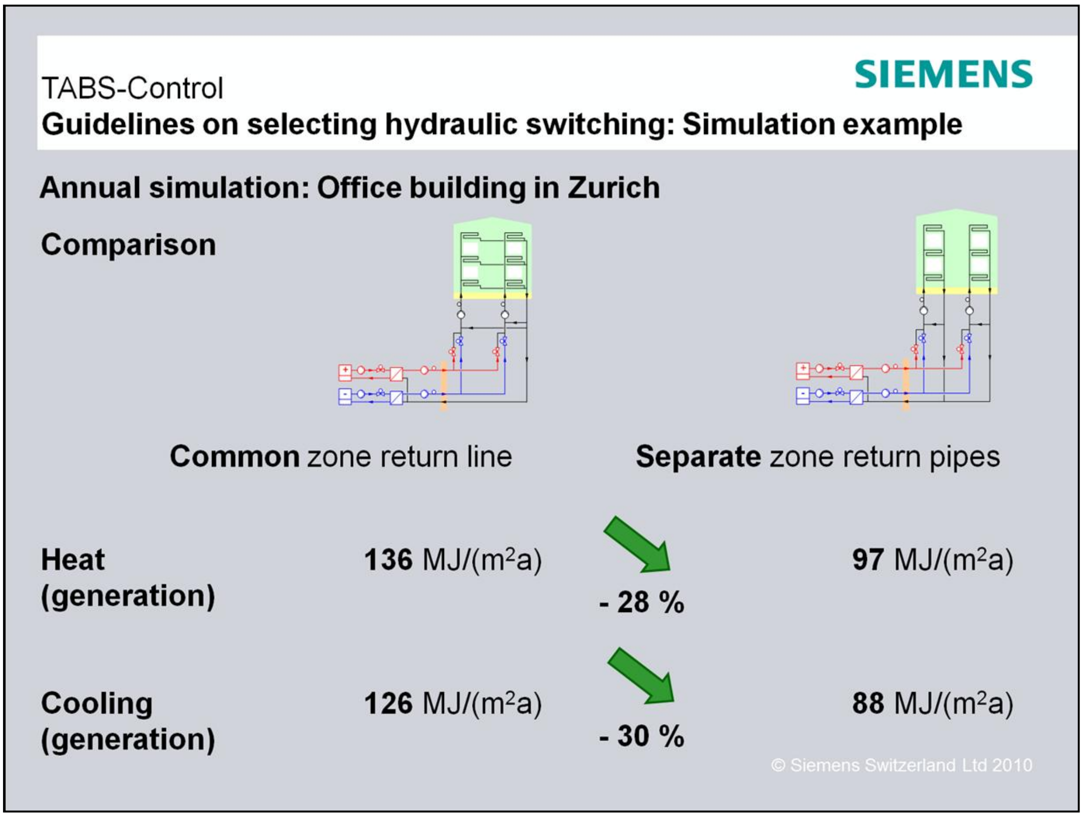


Summary

• The **impact of hydraulic switching** can have tremendous impact on energy demand for some plants.

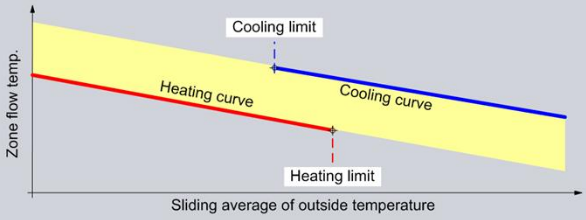
• Which hydraulic switching is suitable, depends on **the building and heat gains**

•A more detailed analysis is required to determine for a concrete case whether separate zone returns would be more appropriate:

- Based on the information in the manual
- Or in critical cases: Through the use of simulations


Correction procedure for heating and cooling curves in buildings using TABS

SIEMENS



The following parameters impact the heating and cooling curves and heating and cooling limits:

- The room temperature setpoints
- The equivalent heat gain limits
- Thermal coupling of TABS as well as
- Thermal properties of building exterior shell

Parameters can deviate from exact values, for example, since:

- not all construction details can be considered
- the calculation model does not exactly correspond with reality
- Planning uncertainties as to knowledge of heat gains exist

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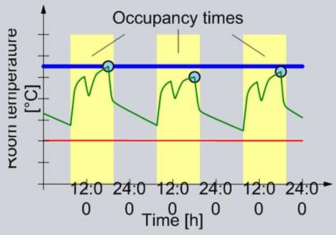
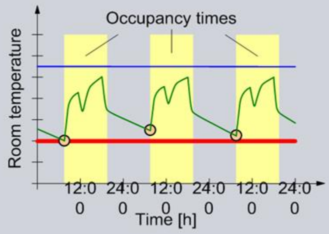
Targeted room temperatures:

during cooling



during heating



Required operational data for correction procedure:

- Daily maximum values for room temperature
- Daily minimum values for room temperature
- Daily whether was heated or cooled, or valve positions of heating and cooling valves
- Sliding average of outside temperature over the past 24 hours
- Parameters for the heating and cooling curves as well as the heating and cooling limits

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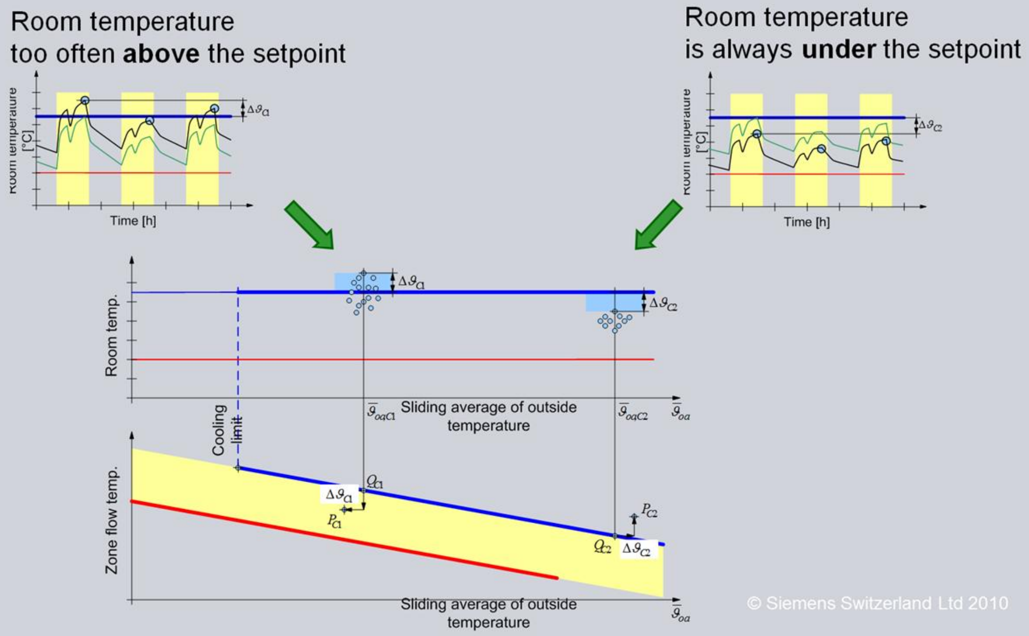
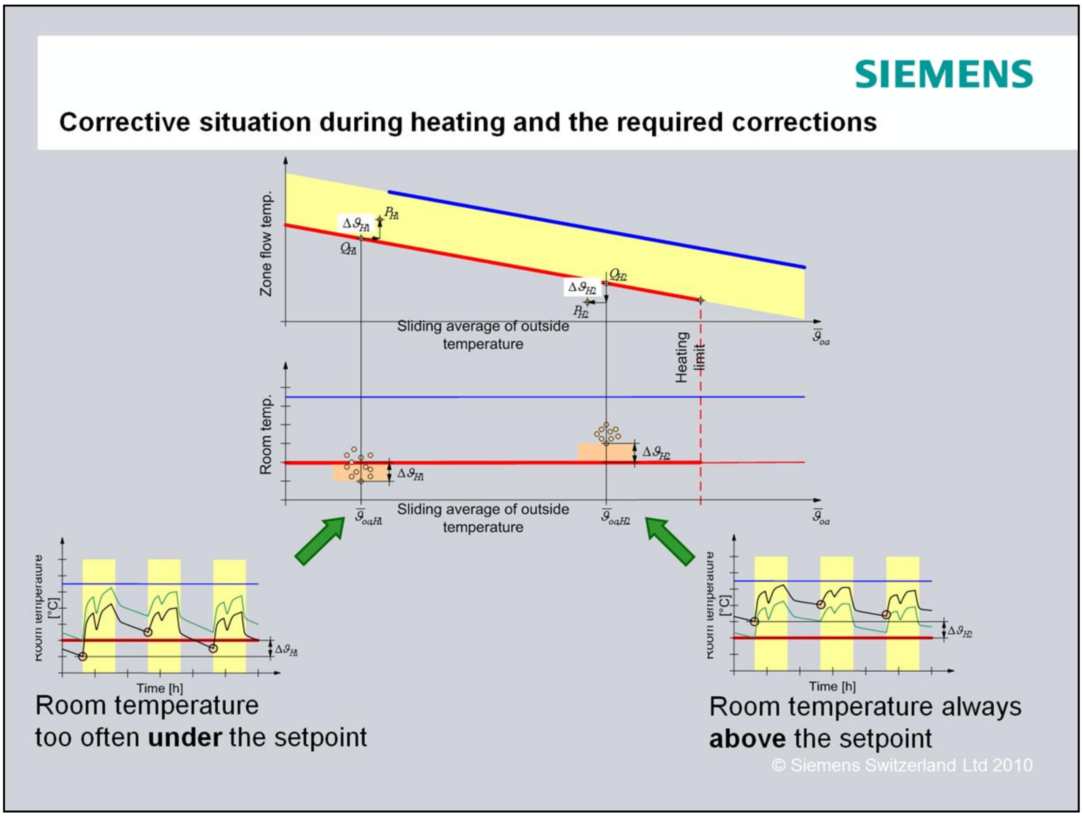
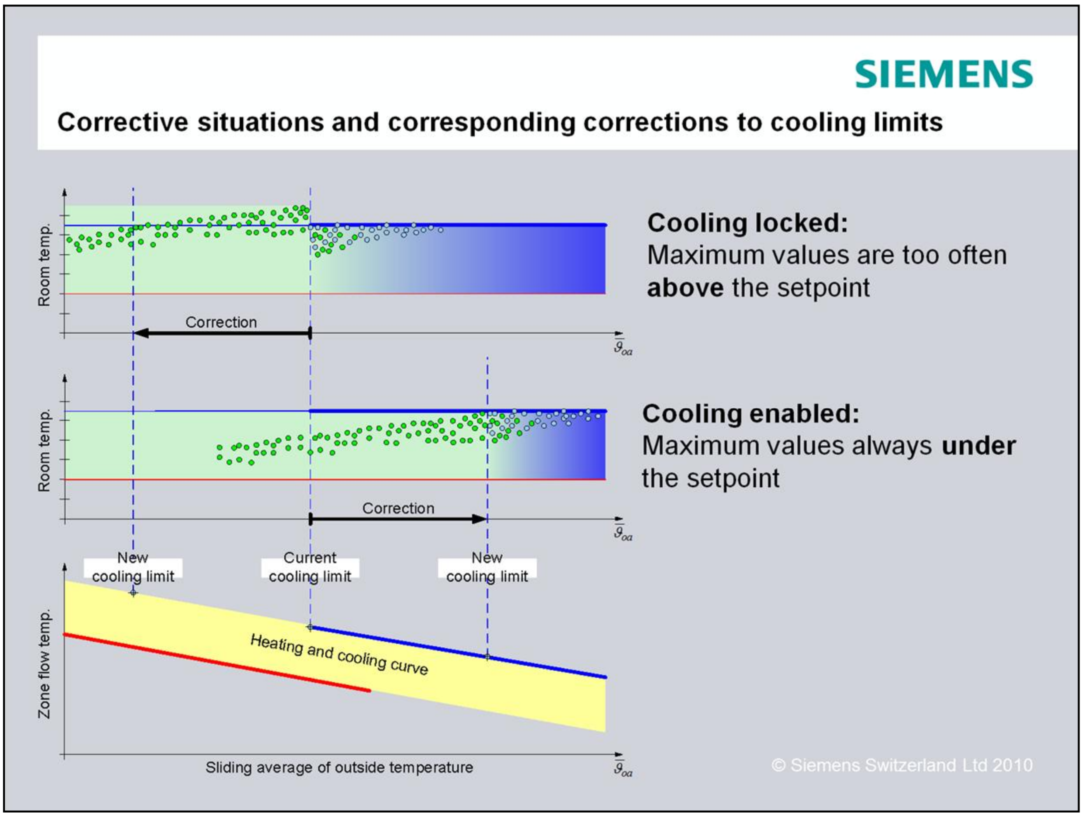
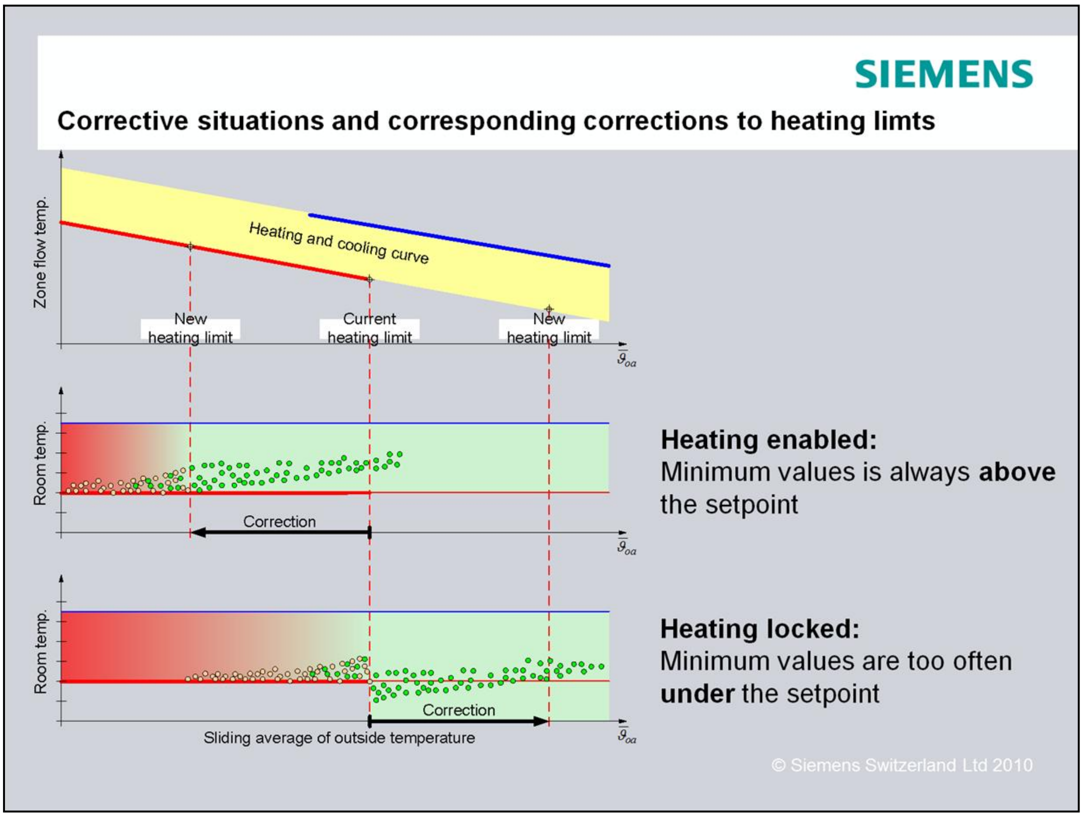
Corrective situation during cooling and the required corrections




SIEMENS
Corrective situation during heating and the required corrections
Zone flow temp.
Sliding average of outside temperature
Heating limit
Room temp.
Sliding average of outside temperature
Time [h]
Room temperature too often **under** the setpoint
Time [h]
Room temperature always **above** the setpoint
© Siemens Switzerland Ltd 2010


Correction procedure for
heating and cooling limits
in buildings with TABS


SIEMENS
Corrective situations and corresponding corrections to cooling limits
Room temp.
Correction
Room temp.
Correction
New
cooling limit
Current
cooling limit
New
cooling limit
Zone flow temp.
Heating and cooling curve
Sliding average of outside temperature
Cooling locked:
Maximum values are too often above the setpoint
Cooling enabled:
Maximum values always under the setpoint
© Siemens Switzerland Ltd 2010


SIEMENS
Corrective situations and corresponding corrections to heating limts
Zone flow temp.
Heating and cooling curve
New heating limit
Current heating limit
New heating limit
Room temp.
Correction
Heating enabled:
Minimum values is always above the setpoint
Room temp.
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Sliding average of outside temperature
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