Ingenieure für Energieeffizienz und Komfort
Österreich
teamgmi

PEAR-Energy Efficient Automation and Control of Buildings

This project is funded by the Austrian Ministry of Transport, Innovation and Technology within the program ‚Stadt der Zukunft' 2nd Call

ISEC-International Sustainable Energy Conference 2018
Anita Preisler, teamgmi
Graz, am 05.10.2018

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Introduction: Starting situation/ current problems

- Expected **operation behaviou**r and **energy performance** of HVAC systems can be achieved in hardly any building from the beginning
- HVAC systems become more and more **complex** which have to be handled by the Facility Management in operation
- **Responsibility** of efficient performance of HVAC systems is given to Facility Management which is not their duty and core know-how
- Appropriate control strategies of HVAC systems should implemented according to the operation conditions and energy efficiency measures set up in the planning phase
- **Lack of information** from planning phase to implementation of control strategies by control engineering during construction phase
- Current commissioning phase and operation test phase focuses on the basic functionality of HVAC system and components not on **energy efficient behaviour**
- Facility Management often **fights for years** to achieve acceptable operation behaviour and energy performance of HVAC systems

Introduction: Goals and Method

- In PEAR a method for a **pre-check** of control strategies adapted to HVAC systems in buildings was developed and tried out in a demonstration building

- Three step method:
  1. Development of appropriate control strategies by dynamic simulations in cooperation with control engineering of building project
  2. Pre-check of developed control strategies with Hardware in the Loop (HIL) method
  3. Monitoring evaluation and optimising operations

- HIL here means:
  - Hardware: applied controller of control company
  - Virtual part: HVAC system in the building (simulated)
  - Loop:

Introduction: Goals and Method

- Demonstration Building:
  - Newly finished Head Quarter of the Austrian „Post“ company in the 3rd district of Vienna with 47.300 m² gross area
  - Usage: Mainly offices and a Shopping Centre
- Three parts of the HVAC system were selected for a PEAR pre-check:
  - Air-conditioning offices
  - Concrete core activation for cooling
  - Free cooling system (dry heat-rejection/sprinkler basin)
- PEAR project partner:
  - AIT – Austrian Institute of Technology (project lead)
  - Österreichische Post AG
  - teamgmi Ingenieurbüro GmbH
  - IBO Österreichisches Institut für Bauen und Ökologie GmbH
  - BPS Engineering Technisches Büro zur Planung Haustechnischer Anlagen GmbH
- **Results shown here:**
  - **Air-conditioning offices: simulation of control strategies and monitoring evaluation**

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Introduction: Demonstration Building

- Integration Process

	2015		2016												2017												2018									
	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
AP1: Project Management																																				
AP2: Requirement Definition																																				
AP3: Control Strategies																																				
AP4: Hardware in the Loop																																				
AP5: Monitoring und Evaluation																																				
AP6: Dissemination																																				

	2015		2016												2017												2018									
	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
Construction Phase (from April 2015)																																				
M1: Integration Control Company from Construction Company in PEAR		♦																																		
M2: Integration of PEAR results in HVAC control by Control Company															♦																					
M3: Handover from Control Company to Facility Management																				♦																
Commissioning/Operating Test Phase																																				
M4: Monitoring data transfer to AIT																					♦															
M5: Move in Shopping Center																								♦												
M6: Move in Post employees																									♦											
Optimising Operations																																				

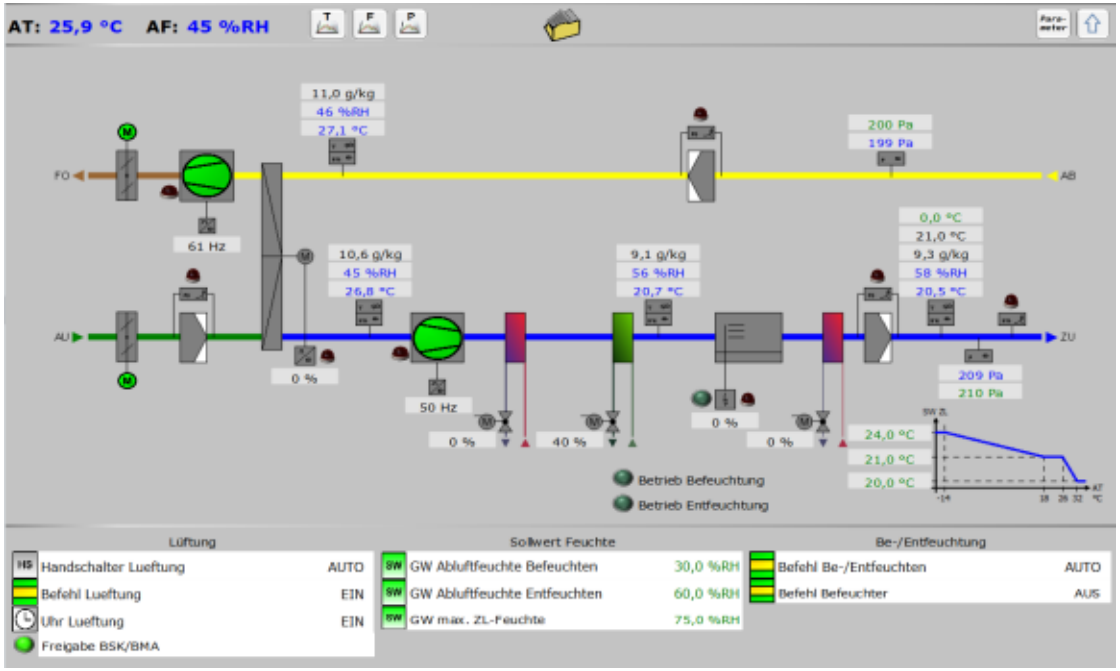
♦ Milestones Construction Process

♦ Milestones for integration of PEAR results in Construction and Operation Process

Results: Air-conditioning offices

- Configuration of Air Handling Units (AHUs)
  - AHU 01: 36.000 m³/h
  - AHU 02: 33.000 m³/h

- Purpose of AHUs:
  - Fresh air supply (35 m³/h*P)
  - Humidity control
  - **NOT**: heating/cooling

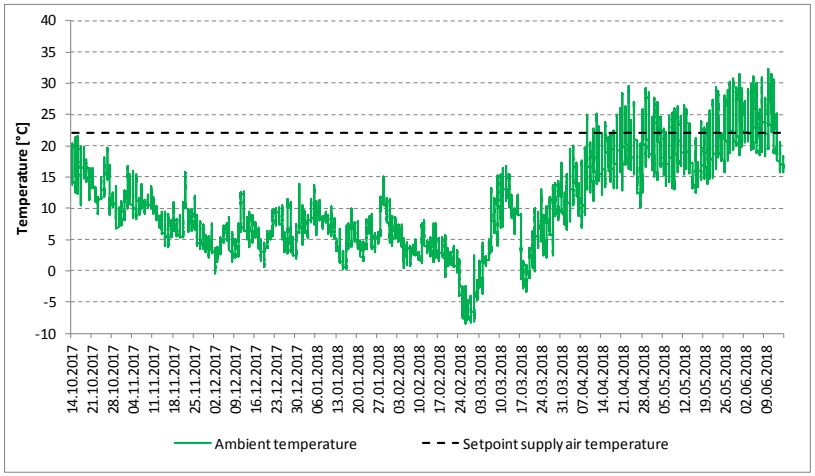


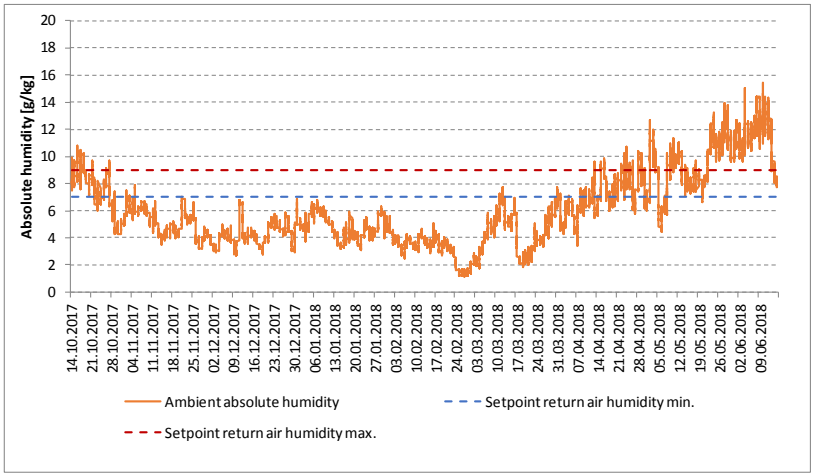
Source: demonstration building,11.04.2018

Results: Air-conditioning offices

- Climate conditions: Monitoring data
  - 14.10.2017 – 15.06.2018 (8 month)

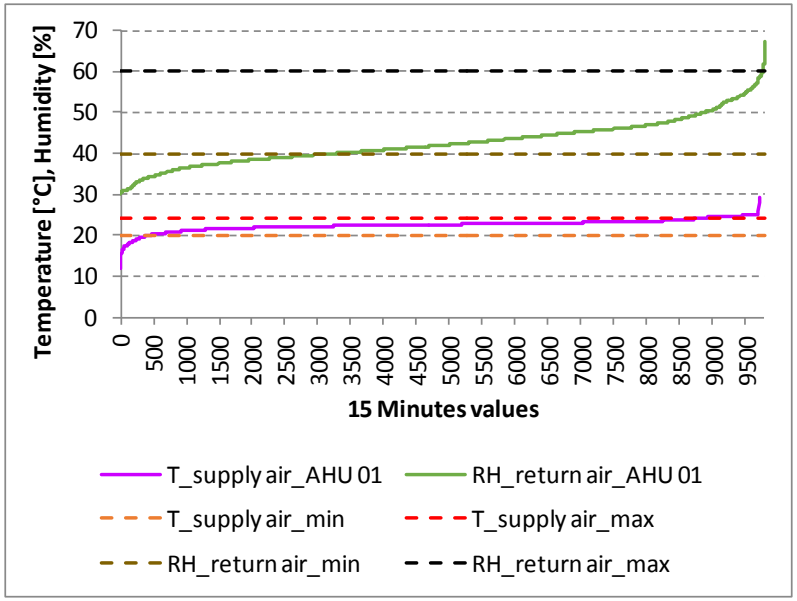
- Set points AHUs: Design values
  - Supply air temperature: 22°C
  - Return air humidity:
    - min. 7 g/kg (40%r.H.)
    - max. 9 g/kg (60%r.H)

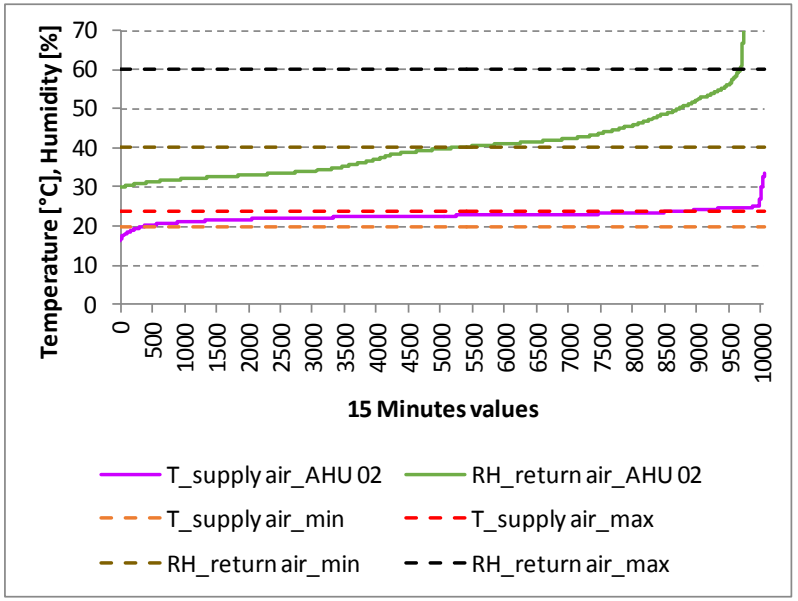




Results: Air-conditioning offices

- Evaluation of achieved Set points: Monitoring data
  - Time period: 19.11.2017 – 15.06.2018
  - Supply air temperature set point can be achieved very well
  - Return air humidity is occasionally below the set point, but still in an acceptable range; AHU 02 had a damaged humidifier in given time period





Results: Air-conditioning offices

- Energy performance of AHUs: Monitoring data
  - Specific fan capacity: lower than design values
  - Electricity demand:
    - AHU 01: 33% higher than design value
    - AHU 02: 37% higher than design value
- Reason: longer run times than foreseen in design phase

		Unit	Design	Monitoring
AHU 01	Volume flow	m³/h	36.000	-
	Specific fan capacity (SFP-4) max.	Wh/m³	1,10	0,82
	Electrical capacity max.	kW	39,60	29,66
	Electricity demand	kWh/(7 month)	42.500	56.500
AHU 02	Volume flow	m³/h	31.000	-
	Specific fan capacity (SFP-4) max.	Wh/m³	1,10	0,95
	Electrical capacity max.	kW	34,40	29,36
	Electricity demand	kWh/(7 month)	41.200	56.300

Results: Air-conditioning offices

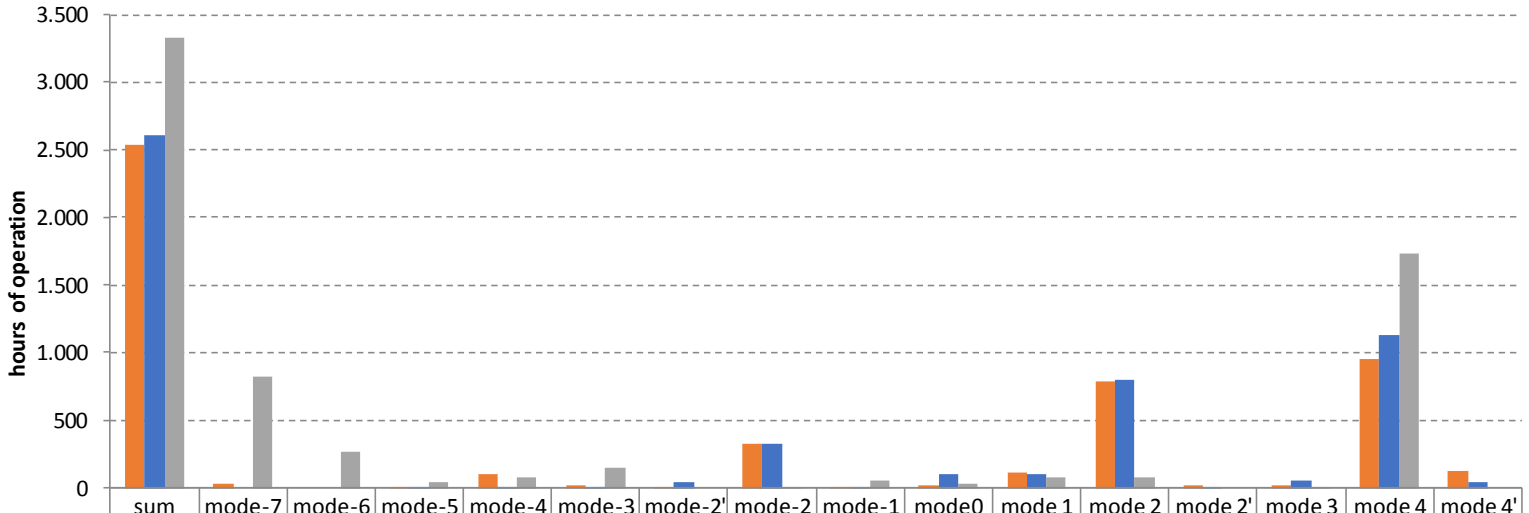
- Comparison of Simulation and Monitoring data
  - Operation modes according to design/simulation (left)
  - Operation modes according to Monitoring data (right)
    - Heating coil II is operating in winter, therefore mode 2‘ and mode 4‘
    - Supply air humidifier is in operation when cooling coil is on, therefore Modus -2‘

mode	enthalpy rotor	heating coil I	cooling coil	humidifier	heating coil II
4	ON	ON	OFF	ON	OFF
3	ON	OFF	OFF	ON	OFF
2	ON	ON	OFF	OFF	OFF
1	ON	OFF	OFF	OFF	OFF
0	OFF	OFF	OFF	OFF	OFF
-1	ON	OFF	OFF	OFF	OFF
-2	ON	OFF	ON	OFF	OFF
-3	ON	OFF	OFF	OFF	ON
-4	ON	OFF	ON	OFF	ON
-5	OFF	OFF	ON	OFF	OFF
-6	OFF	OFF	OFF	OFF	ON
-7	OFF	OFF	ON	OFF	ON

mode	enthalpy rotor	heating coil I	cooling coil	humidifier	heating coil II
4'	ON	ON	OFF	ON	ON
4	ON	ON	OFF	ON	OFF
3	ON	OFF	OFF	ON	OFF
2'	ON	ON	OFF	OFF	ON
2	ON	ON	OFF	OFF	OFF
1	ON	OFF	OFF	OFF	OFF
0	OFF	OFF	OFF	OFF	OFF
-1	ON	OFF	OFF	OFF	OFF
-2	ON	OFF	ON	OFF	OFF
-2'	ON	OFF	ON	ON	OFF
-3	ON	OFF	OFF	OFF	ON
-4	ON	OFF	ON	OFF	ON
-5	OFF	OFF	ON	OFF	OFF
-6	OFF	OFF	OFF	OFF	ON
-7	OFF	OFF	ON	OFF	ON

Results: Air-conditioning offices

- Comparison of Simulation and Monitoring data
  - Additional modes mode 2‘, mode 4‘ and mode -2‘ only occur on few hours in transition time
  - Mode 2 (without humidifier) operates too often → is reflected in not reaching humidity set point



	sum	mode-7	mode-6	mode-5	mode-4	mode-3	mode-2'	mode-2	mode-1	mode0	mode 1	mode 2	mode 2'	mode 3	mode 4	mode 4'
AHU 01	2.541	28	0	6	100	14	6	324	8	24	113	784	23	16	956	122
AHU 02	2.612	0	0	4	6	1	43	322	3	101	98	800	5	59	1.126	38
Simulation V14	3.326	826	268	39	72	144	0	9	49	25	74	82	0	7	1.731	0

Conclusions I

- Control air-conditioning offices:
  - Supply air temperature set point can be achieved very well
  - Return air humidity is occasionally below the set point, but still in an acceptable range; AHU 02 had a damaged humidifier in given time period
  - Humidifier is operating when cooling coil is “on” in transition time; this should be monitored further in summer time to see if it is an operation failure or not
  - The high maximum set point of 24°C of supply air when the outside air is very cold should be reduced to generally 22°C as the AHUs have no heating purpose → heating coil II is probably not necessary for heating modes as intended
  - Electricity demand of AHU 01 is 33% and AHU 02 37% higher than foreseen in design phase due to longer operation times:
    - Design phase: 07:00 – 19:00
    - Operation: 06:00 – 21:00; sometimes also on the weekends
    - AHUs have **no** heating or cooling function
    - Purpose of AHUs: fresh air supply and humidity control → only useful when people are present

Conclusions II

- Experience of PEAR method in demonstration building:
  - HIL pre-check of control strategies showed various **programming failures** in advance
  - The **operation behaviour** and **energy performance** of HVAC systems is close to the expected values right from the beginning by using PEAR method
  - **Deviations** or **operation failures** can be more easily identified by comparison of monitoring data with simulation results
  - **Lack of information** from planning phase to implementation of control strategies by control engineering during construction phase is closed → control strategies are set up together
  - **Quality assurance** and **proper commissioning** of HVAC system is still necessary and can not be replaced by PEAR method
  - **Responsibility** of efficient performance of HVAC systems is given back to HVAC planner and control engineering company who have the necessary know-how