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Saving energy and improving comfort through plant optimization using practical examples

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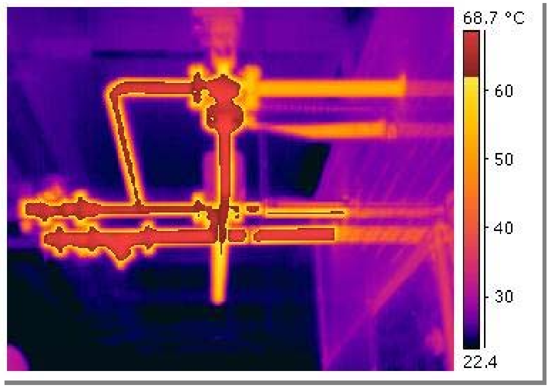
Improving energy efficiency: Where to start with?

- A study (1) identified energy saving potentials within non-residential office buildings high as:
  – 30% for thermal (caloric) energy
  – 15% for electrical energy
- Another study (2) even identifies 23% potential savings for electrical energy.
- 25% of the saving potential can be addressed with building automation and control systems.
- The typical consumption for thermal and electrical energy is around 50%:50%. But electrical energy is more expensive!

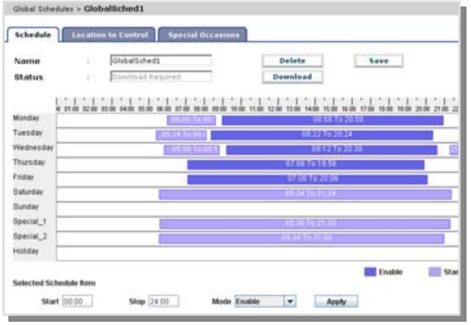
Sources:
(1) „Efficiency of public buildings“ (Prof. Hirschberg)
(2) „Energiecontrolling in Bürogebäuden“, Stadt Frankfurt, 2002. The study included 13 non-residential buildings.

Low capital investment actions (1)

- 50% of the electrical energy consumption in buildings is used for air transportation (80%) and for cooling purposes (20%).
- The purpose of the low capital investment actions described herein is to improve the ventilation and air conditioning effectiveness. Examples are:
  - Switch off ventilation and air conditioning if rooms are not used any more. Immediate pay off!
  - Insulation of the piping system. Thermography may help to identify weak spots.



Low capital investment actions (2)



- Adjust time programs and schedules
  - HVAC systems often never got their original time programs changed. But occupancy did change in the meantime!
- Variable speed drives (inverters) can help to save up to 50% of the electrical energy consumption.
  - Energy savings apply to fans and pumps
  - Enjoy increasing comfort
  - Simple to talk to
    - Modbus, LON, Profibus or BACnet

Variable speed drive efficiency

	Controlled by inlet guide vane (Dralldrossel)	Controlled by variable speed drive
Full load (100% air flow)	15 kW → 10 kW **Losses high as 5 KW** **Efficiency factor 67%**	16 kW → 10 kW **Losses high as 6 KW** **Efficiency factor 63%**
Partial load (50% air flow)	10,3 kW → 1,3 kW **Losses high as 9 KW** **Efficiency factor 13%**	2,9 kW → 1,3 kW **Losses only 1,6 KW** **Efficiency factor 45%**

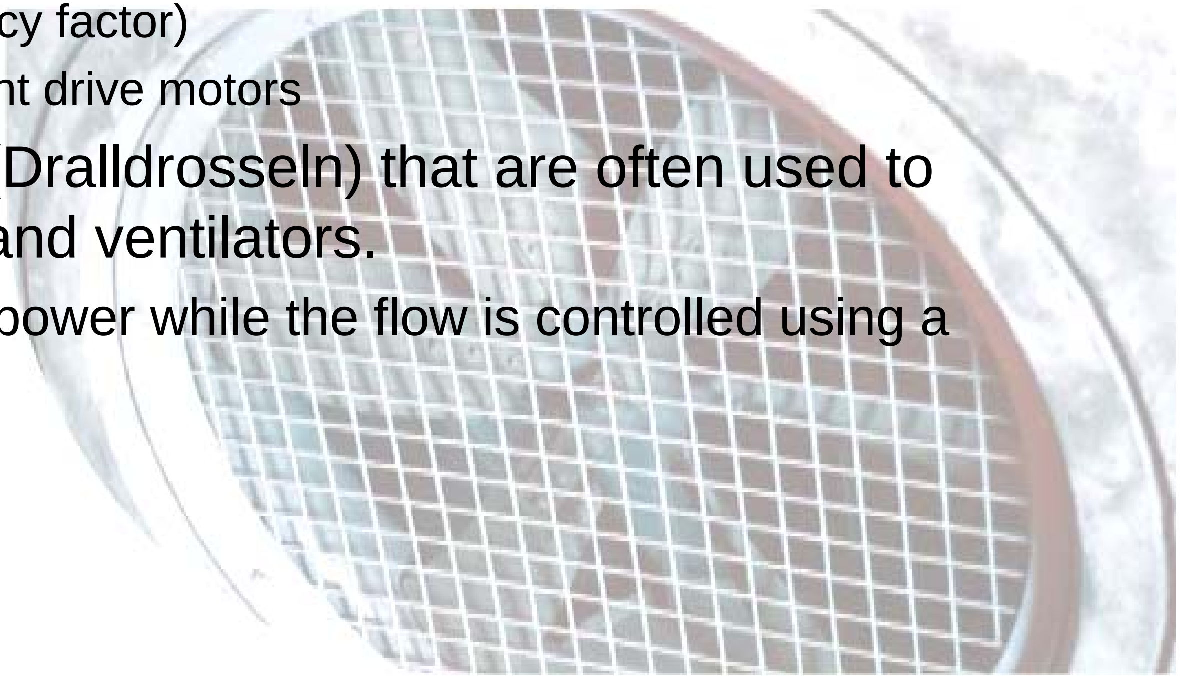
Source: Steinigeweg Beratende Ingenieure VBI

Low capital investment actions (3)

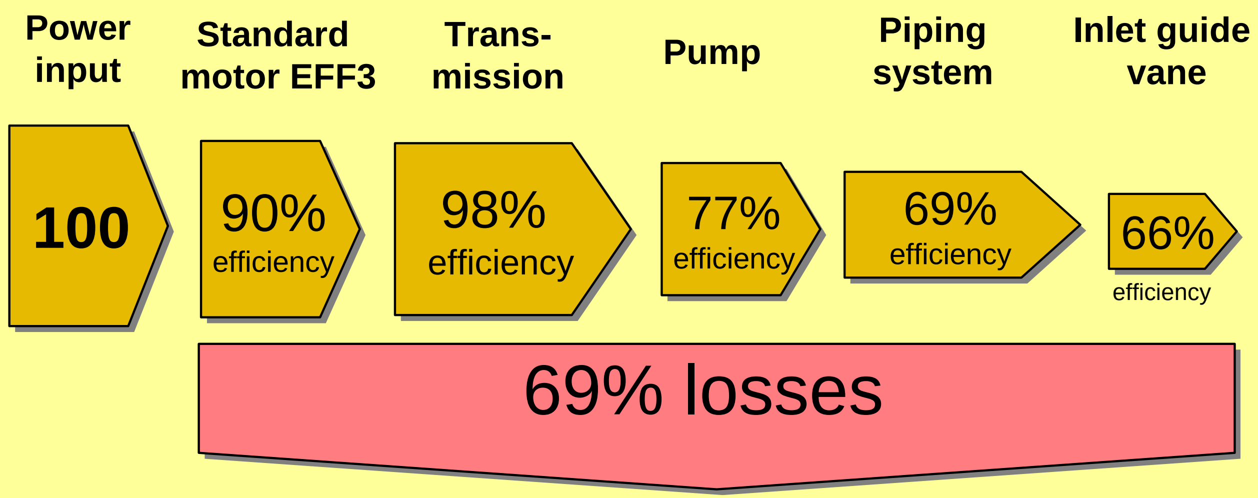
- Adjust ventilation and air conditioning to the actual needs
  - Air volume can be controlled using CO_2 sensors (non-smoking areas) or mixed gas level sensors where smoking is allowed.
    - Max. CO_2 concentration recommended: 700 ppm.
    - The “Pettenkofer Wert” recommends CO_2 concentration of max. 1.000 ppm.
    - CO_2 is considered a good indicator for air quality.

Low capital investment actions (4)

- Choose high efficient ventilators and pumps
  - A study prepared by Gebhardt shows a 25% energy saving potential that can be activated through
    - the usage of high energy efficient ventilators
      - 97% of ventilator life-cycle-cost are operational cost!
    - the replacement of fan belts (95% efficiency factor) by flat belts (with 98% efficiency factor)
    - the usage of energy efficient drive motors
- Replace inlet guide vanes (Dralldrosseln) that are often used to control the flow for pumps and ventilators.
  - The drive still works at full power while the flow is controlled using a mechanical resistance.

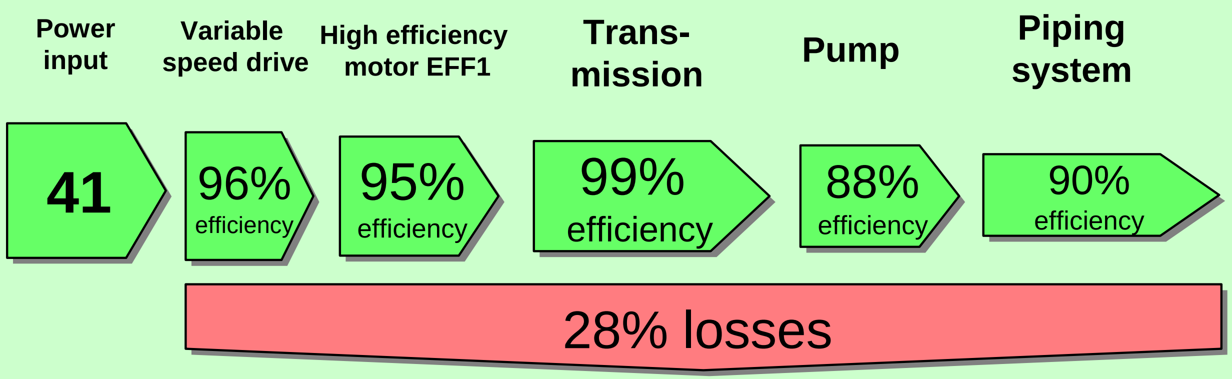


Standard versus high efficiency pump drive



Output power: 31
(31% system efficiency)

Standard equipment

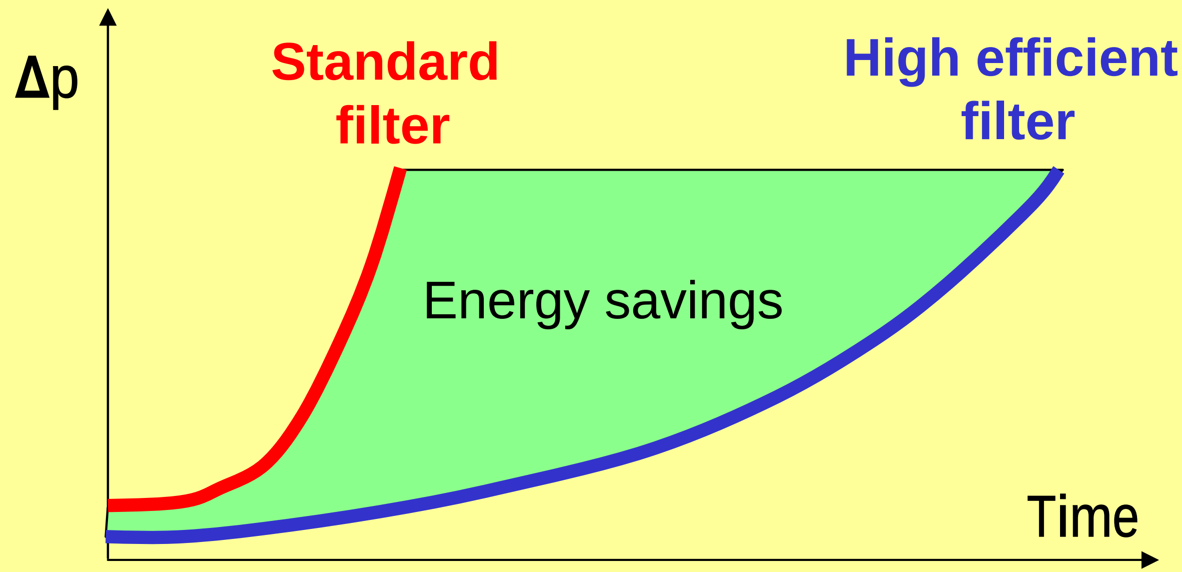


Output power: 31
(72% system efficiency)

High efficiency equipment

Low capital investment actions (5)

- High performance air filters to significantly reduce total life cycle cost
  - Higher Δp of standard filters results in higher energy cost
  - Standard filters need to be replaced earlier compared to high efficient filters thus resulting in further investment, labour and disposal cost.



Energy optimization with intelligent DDC (1)

- State of the art BACS/DDC*) systems contain various energy optimization applications such as:
  - Peak power demand control
    - Turn off selected equipment before demand peaks show up.
  - Duty cycle
    - Use staggered duty cycle periods to reduce equipment ON time.
  - Enthalpy control
    - Control system takes into account both the temperature of the outside air (called sensible heat) and the humidity (latent heat) when making a decision whether to cool with outside air (cheaper) or use the compressor (more expen-sive) instead. The combination of sensible and latent heat is called total heat or enthalpy.

*) Building Automation and Control Systems / Direct Digital Control

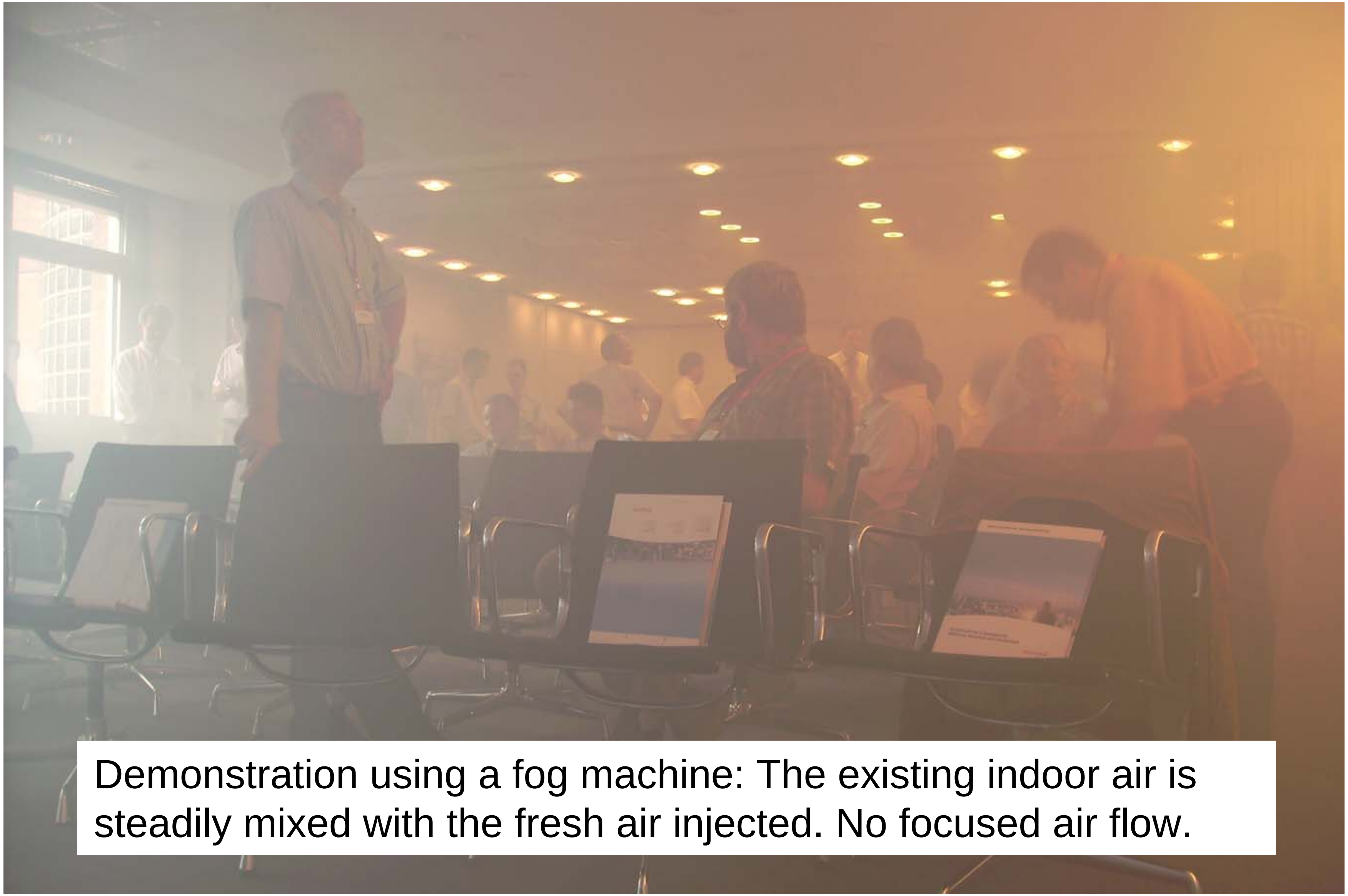
Energy optimization with intelligent DDC (2)

- Night cycle
  - Turn equipment on/off during non-occupancy hours to maintain room temperature within acceptable limits.
- Night purge
  - During cooling season purge building with cool outside air in the early morning.
- Optimum start
  - Initiate HVAC system before occupancy time to bring indoor temperature within comfort zone by occupancy time.
- Optimum stop
  - Shut down HVAC system before occupancy ends: late enough to maintain comfort level until end of occupancy period.
- Zero energy band
  - Reset cooling & heating set point to keep room temperature within comfort zone at a minimum energy consumption level.

Energy optimization with intelligent DDC (3)

- „Bauer Optimization strategy“ major benefits:
  - Steady mixture of the existing indoor air with the fresh air injected.
  - Uniform mixing of the existing indoor air with fresh air injected.
  - Unfocused air flow throughout the room.
  - Avoidance of draught and islands of polluted air.
  - Reduction of supply and exhaust air and thus reduction of the electrical energy and caloric energy required.
    - Avoid short circuits between supply and return air.
    - The actual amount of fresh air needed is measured based on demand.
  - Increased tenant and occupant comfort
    - low air flow velocity and
    - optimum temperature distribution from the ceiling to the floor.

„Bauer Optimization strategy“ major benefits:



Demonstration using a fog machine: The existing indoor air is steadily mixed with the fresh air injected. No focused air flow.

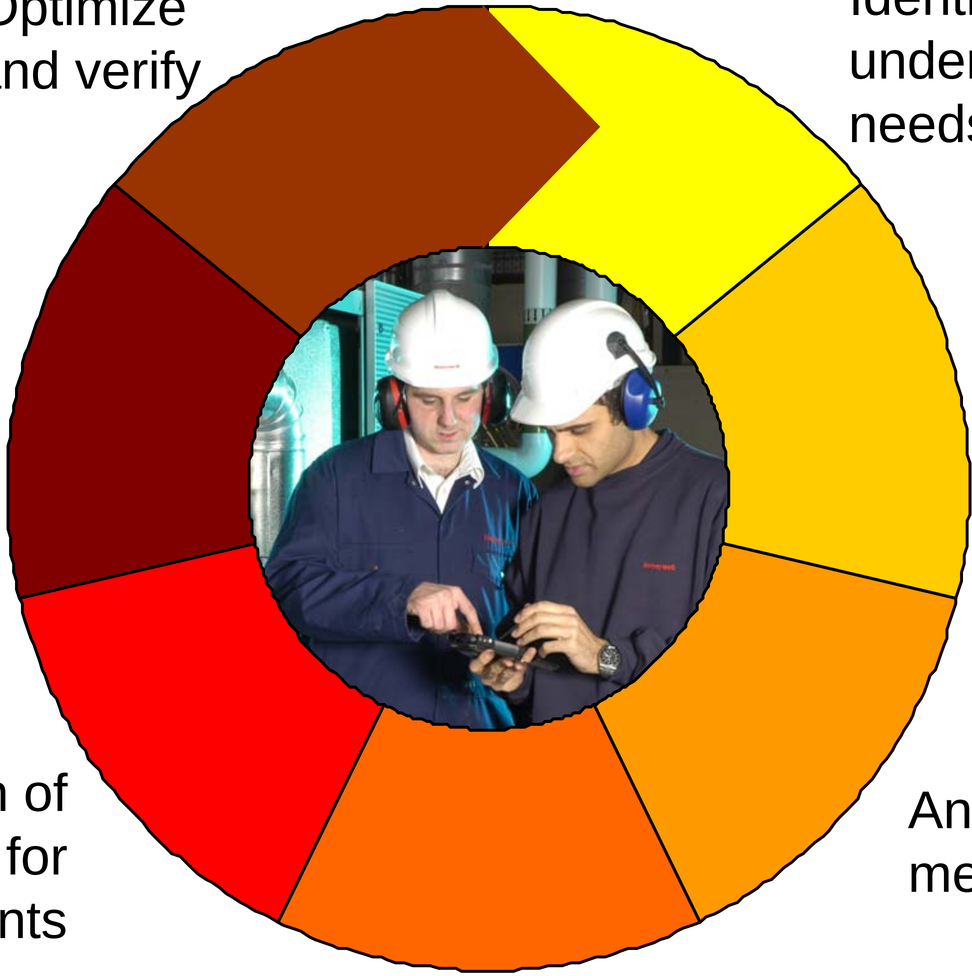
Energy Management System

- Controlling energy usage using an Energy Management System
  – You Can't Manage What You Can't Measure!
  – Helps to identify weak spots in regards to energy consumption and usage.
  – Provides customizable and flexible reporting and powerful analysis capability.
  – Allows for trending, modeling and forecasting as well as for cost tracking and allocation.
  – Avoids peak energy demands that drive up cost.
  – Supports tenant extras billing.
  – Supports benchmarking of facilities across the enterprise.

What exactly fits to my needs?

- Various opportunities to improve energy efficiency and increasing the comfort are available.
- But what exactly fits to my building needs?

Optimization project flow



Typical energy optimization project flow

1. Understand customer and operational needs
2. Take measures (temperature, current, actuator signals, CO_2, LUX) to understand the baseline.
   – Mechanical meters may also be included into the monitoring using meter cameras.
3. Evaluation and analysis of data collected.
4. Creation of model calculations based on the measured data.
5. Develop optimization concepts and possible alternatives.
6. Determine possible savings and costs for the retrofit scope of work.
7. Creating a payback calculation.
8. Prove the savings after the retrofit work has been done.
9. Further optimization during the operational phase.

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Project example:
Municipal Hospital in Dessau

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Municipal Hospital in Dessau

- The Municipal Hospital Dessau is a focus of hospital care and academic teaching at the Martin Luther University Halle-Wittenberg.
- It has got about 700 beds available.
- Each year approximately 26,000 patients receive hospital treatment.
- Nearly all disciplines of medicine are offered.
- The hospital has got installed a state of the art BACS (Building automation and control system) from Honeywell, with about 10,000 data points distributed to 100 DDC automation stations.

The optimization project

- In 2007 the hospital department of construction and building management accomplished an energy optimization project together with Honeywell Building Solutions. The goal was to reduce the amount of energy required to operate the ventilation and air conditioning plants.
- The project was considered to be a model for energy optimization of further HVAC plants.
- The ventilation and air conditioning system that had been selected first, supplies secondary rooms and hallways East, Mid and West at level "0" to "2" of the inpatient ward (Bettenhaus) no. 3.
- The idea was to use the existing automation and control to optimize HVAC system operation and prove whether or not it is possible in the various zones to
  - shut off supply air during night time and
  - reduce the supply- and exhaust air volume depending on the actual room conditions (temperature and CO_2-level)

Calculation of potential savings

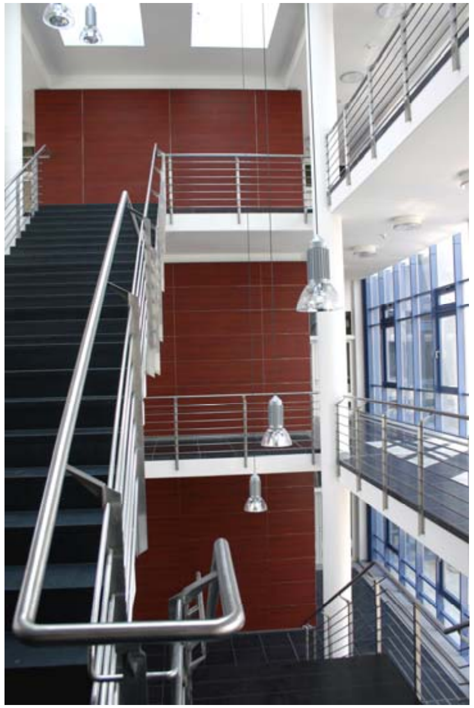
- A test proved that the considered means did not compromise comfort.
- Calculated savings for one HVAC system only.

Energy	Actual consumption	Estimated consumption with optimization	Estimated savings
Electrical	100%	84,5%	15,5%
Calorical	100%	65,4%	34,6%
	Calculated savings		€ 11.003

- Payback calculation:
  - Costs for installing and programming € 22,604, -
  - 11,003 savings per year € 11,003,-
- Payback reached after 2 years only!

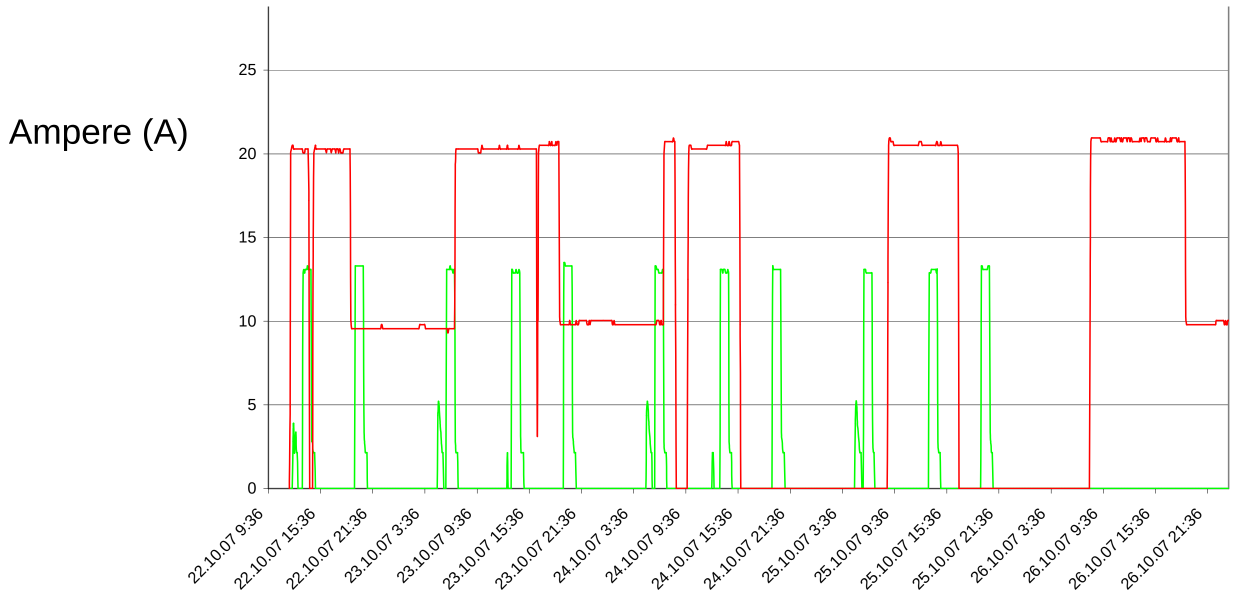
Optimization implemented

- Installed variable speed drives for supply and exhaust fans
- Implement temperature and CO_2-based zone control
- Shut of supply air during night (monitored by air quality sensors)



Data analysis for optimized plant operation

- Analysis of data collected
  - The analysis of the measurements show the power consumption of the supply air ventilator before and with the optimization in place.
  - The new the air quality sensors in conjunction with the room temperature sensors make sure that the comfort limits do not get violated.



March 07 (before the project started)
October 07 (with optimization in place)

Savings with optimization in place

Energy	Actual consumption without optim.	Calculated consumption with optimization	Actual consumption with optimization in place	Total Savings in %
Electrical	100%	84,5%	35%	65%
Calorical	100%	65,4%	34,4%	65%
Total energy savings	**100%**	**73%**	**34,6%**	**65,4%**

- Payback calculation:
  - Costs for installing and programming € 22,604
  - Savings per year € 26,857
- Payback time : **10 month only!**

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HVAC plant optimization at a thermal spa in the state of Hesse

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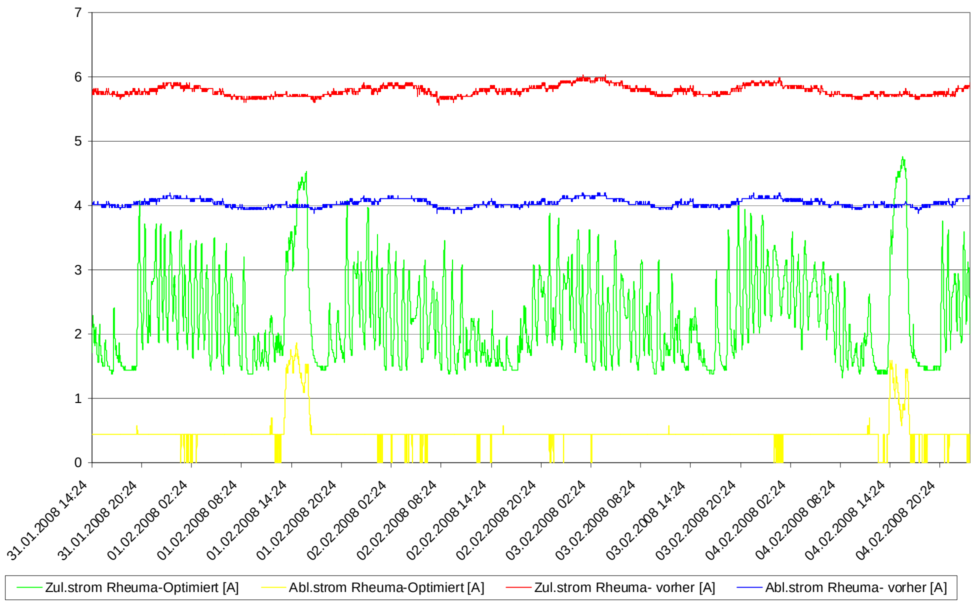
Application of the Bauer Optimization strategy

- 10 HVAC systems for thermal spa (including swimming hall, therapy, therapy pool, rheumatism treatment pool, convention hall)
- The energy retrofit project applied to the thermal spas' HVAC systems included
  - New control cabinets
  - New sensors (CO_2, air pressure sensors)
  - New actuators (flap drives)
  - Installation of variable speed drives
  - Optimization of the DDC control loops using the Bauer Optimization modules.

Carbone dioxide and air pressure sensors

Measures taken at the Thermal Spa

- Overall electrical power consumption for the HVAC plants could be reduced by 48%.
  - Therapy pool (Bewegungsbad)
    - 33% of the electrical power could be saved.
  - Rheumatism treatment pool (Rheumatempel)
    - 72% of the electrical power could be saved.



Without optimization:
- Supply air (A)
- Exhaust air (A)

With optimization:
- Supply air (A)
-Exhaust air (A)

Data taken from the rheumatism treatment pool

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HVAC plant optimization at the Goethe University Frankfurt am Main using the Bauer optimization strategy

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The Goethe University project

- The project:
  - Optimization of HVAC plants at 6 lecture halls or ...
  - How to avoid 45 t of CO_2-emission per year!
  - Lecture halls I – IV,
    - 200 seats each,
    - Supplied by a HVAC plant with a capacity of 8.500m³/h
  - Lecture halls V - VI,
    - 600 seats each,
    - Supplied by a HVAC plant with a capacity of 19.500m³/h

Energy optimization project implementation

- The project included the installation of
  - Inverters/Variable speed drives,
  - air quality sensors and
  - various sensors like three temperature sensors (to prove even temperature distribution) in the lecture halls, room pressure sensors
  - the Bauer optimization strategy DDC programs.

Inverters for supply and exhaust air ventilators

Electrical energy savings

- The electrical power consumption was reduced by
  - 50% for the supply air drives
  - 40% for the exhaust air drives

- Total electrical energy savings for the HVAC plant drives: 44%

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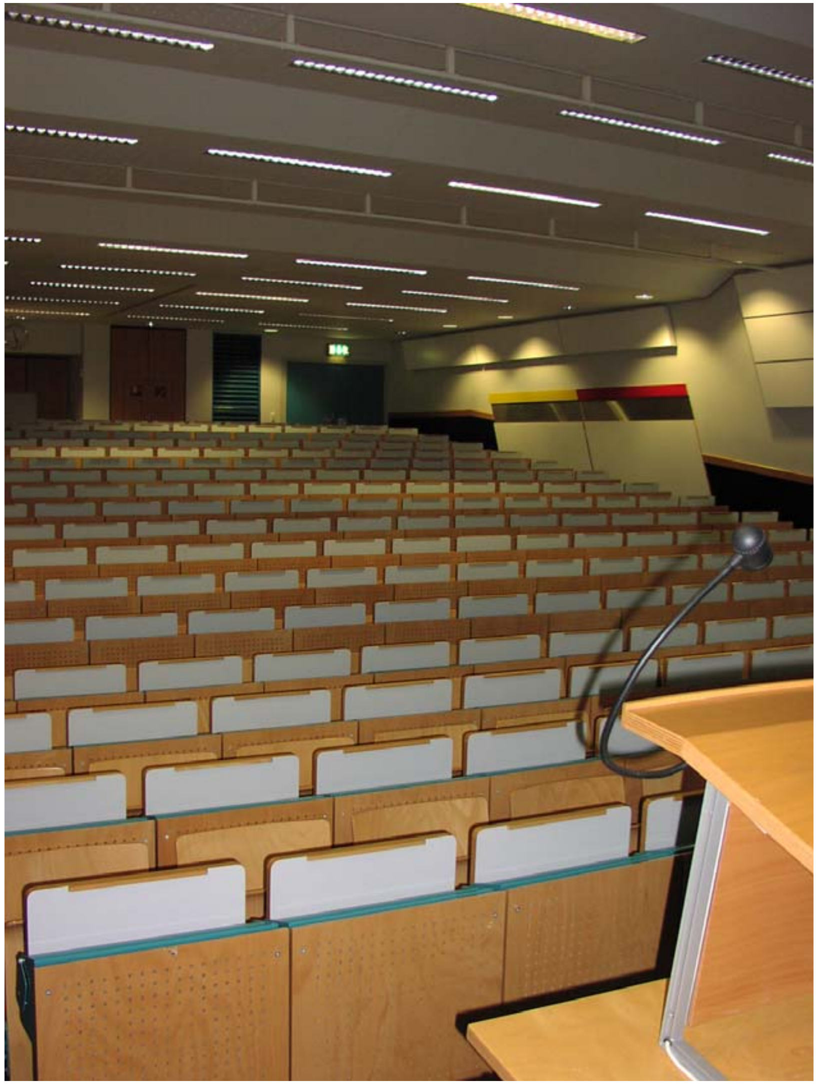
- Results from the Goethe University
  - No complaints among students (verified with interviews)
  - Savings of 45 t CO_2-emissions per year
  - Proved by measures:
    - No compromise to room conditions (temperature and humidity)



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Thank you for your attention!

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