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Heat Recovery Coefficient More Than Doubled

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Heat Recovery System Controller Ensures High Degree of Efficiency

Central outside air intake to supply the hospital’s HVAC system (Photo: Konvekta AG)

The Munich-Bogenhausen Hospital, a 1,000-bed facility, has replaced its heat recovery system with a high-efficiency run-around energy recovery system (RAERS). Its special feature is an innovative heat recovery system controller. The system supplier, Konvekta AG from St. Gallen, Switzerland, guarantees a total energy effectiveness of 87% on a long-term basis.

Hospitals are large-scale consumers of heat, cold and electricity. Therefore, recovery of heat from the exhaust air of ventilation and air-conditioning is of major importance. Run-around energy recovery systems (RAERS) are typically installed in hospitals since they can be easily integrated into customary ventilation and air-conditioning systems. An important advantage of RAERS from a technical and air pollution control point of view is that heat transfer via a circulation medium also guarantees complete separation of supply air and exhaust air. This is of particular importance to hospitals.

Insufficient Control Concept

The disadvantage of many RAERS from the 1970’s and 1980’s is that exchange efficiency is often marginal, one reason being that RAERS and their control systems were predominantly designed to function individually and usually several trades were involved in building such systems. Their exchange efficiencies were marginal, because they were usually based on standard components and the control concept was configured on a rather rudimentary basis. When installed, they typically did not perform efficiently because the system did not include an advanced controller to address operating conditions not considered as part of the original design parameters.

Central Supply Air – Decentralized Exhaust Air

Due to the integrated air-conditioning concept (central air intake arranged on the 2nd basement floor, preheating, filtering, subsequent decentralized after-treatment, and decentralized exhaust air stations arranged on the roof), a RAERS for heat recovery was the only option for the Munich-Bogenhausen Hospital (commissioned in 1984).
The basic requirement was to feed the outside air volume (approximately 600,000 cfm) centrally through a concrete intake structure to concrete supply air stations, and to preheat the air to a constant 60 °F by means of heat recovery from ten exhaust air stations. The actual air treatment and reheating occurred decentralized in function-related supply air units.
The system designers originally assumed an efficiency of 50 % for the RAERS design. After a few years of operation it became evident that the RAERS did not achieve the specified efficiency, and additional energy from the district heating system was required to achieve design temperatures. Also, the RAERS control system turned out to be rather imprecise and costly (energy) with marginal efficiency.

“Heat Recovery Optimization” Study

Increasing energy cost and the need for a system upgrade led to close scrutiny of the unsatisfactory performance of the heat recovery system. In the thesis “Energetic Optimization of Heat Recovery at Munich-Bogenhausen Hospital” (Christian Stürzer; advisor Prof.

Bogenhausen Hospital in brief

Hospital construction	1977 to 1982
Commissioning	1984
Beds	951
Day-clinic spaces	55
Employees	2110
Specialized clinics	19
Intensive care units	7
Operating rooms	15
Building length	650 ft
Building width	Max. 320 ft
Floors	10 (3 below grade)
Heated net floor area	1,590,000 sq ft

The Munich-Bogenhausen Hospital was one of the first of its kind with approximately 1000 beds. (Photo: Munich-Bogenhausen Hospital)

Supply air station for 470,000 cfm: four existing ventilators with blade adjustment supply the building with the necessary outside air.

Instead of eight pumps, today two circulation pumps controlled by frequency converters provide an energy and performance optimized flow.

Dr. Ing. Hartmut Pietsch, University of Applied Sciences, Munich), an extensive monitoring program provided evidence that the existing RAERS was inadequate and had a high risk of failure due to stop valve corrosion.

New heat transfer wall from Konvekta in the supply air station for basic heating of outside air to constant 60 °F. (Photo: Kulle & Hofstetter)

Identify Energy Guzzlers

Annual energy balances for preheating outside air revealed that only about 37% was provided by heat recovery, 56% was purchased from the district heating system and 7% was provided by waste heat from the chiller. The eight RAERS circulation pumps connected in series turned out to be energy guzzlers because they were oversized and had poor circuit design. The over-sizing is, among other things, due to the fact that the standards and guidelines used at the time stipulated approximately 20% higher intake air volume requirement. Today the intake air volume (in accordance with DIN 1946, Part 4) is only about 470,000 cfm.

Three Modernization Alternatives to Choose from

To verify the apparent over-sizing during the conceptual design of the new heat recovery system and to provide realistic profitability calculations, the thermal processes in the hospital were simulated using the “DOE-2” building simulation program, optimized and compared with systems available on the market. Three alternatives were simulated for the optimization of the system:

- Complete Upgrade
- Partial Upgrade
- Complete Upgrade with Adiabatic Cooling

New heat transfer wall from Konvekta and air filters (Photo: Kulle & Hofstetter)

The heat recovery air coolers, connecting ducts, controls and stop valves were completely replaced in the course of the RAERS upgrade.

The piping system (according to Tichelmann) from 1979 combines ten exhaust air stations on the roof with the supply air station on the 2nd basement floor.

All data from the heat recovery controller can be accessed on a touch screen. Photo: Albert Holzbauer, longtime heat recovery system attendant.

Alternative 1 – "Complete Upgrade"
In Alternative 1 "Complete Upgrade", the existing heat exchangers for intake air will be replaced. The Konvekta system was selected as the reference system for calculations.

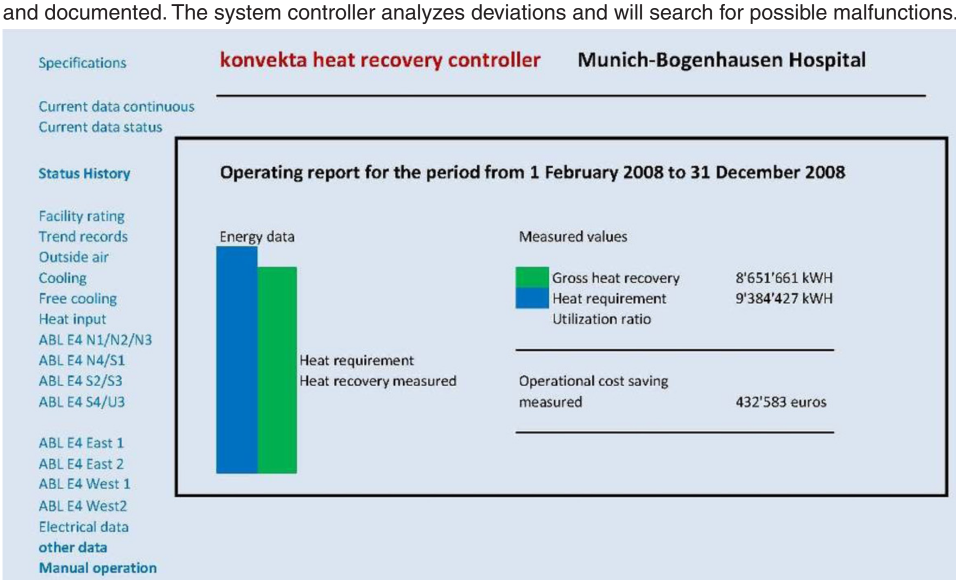
Upgrade Includes:

- Upgrading both the heat exchanger wall in the supply air station in front of the air filter wall (filter preheater in accordance with VDI [Association of German Engineers] 6022) and the heat exchanger wall after the air filter wall. Dry operation of the air filters in accordance with VDI 6022. At intake air temperatures above 60 °F, the flaps above the heat exchanger walls will open and the air resistance is lowered accordingly.
- Replacement of eight circulation pumps by two newly sized pumps controlled by frequency converters.
- Replacement of exhaust air heat exchangers in the decentralized exhaust air stations with newly sized heat exchangers.
- Installation of a heat recovery controller with a "master" in the cooling station and "slaves" in each exhaust air station.
- Replacement of plate heat exchanger #3: free cooling from the refrigeration plant coolers is introduced into the system by of this heat exchanger.

The energy requirement for heating the outside air as well as heat recovery will be permanently documented. The controller seeks and analyzes possible errors in the event of deviations.

Alternative 2 – "Partial Upgrade"
Alternative 2 as a "Partial Upgrade" includes only the replacement of the outside air heat exchangers (same as Alternative 1), but with retention of existing exhaust air heat exchangers.

The energy requirement to heat the supply air and the energy recovered are continuously measured and documented. The system controller analyzes deviations and will search for possible malfunctions.



Alternative 3 – "Complete Upgrade with Adiabatic Cooling Through Exhaust Air Humidification"
Alternative 3 "Complete Upgrade with Adiabatic Cooling" corresponds to Alternative 1, but with additional exhaust air humidifiers for adiabatic cooling of exhaust air. This additional function will provide a portion of the cooling requirement in the summer and relieve the existing chillers.

A dynamic profitability calculation of the three alternatives resulted in a clear decision for Alternative 1 ("Complete Upgrade"). The Hospital owners and management team also supported this alternative. The following facts justified this choice:

- Lowest payback period with 4.58 years (in relation to energy prices of 2004)
- Capital surplus of about $9.4 million (without sales tax) in 15 years with investment cost of approximately $2.6 million

For the hospital this means:

- About 78 % energy cost savings in comparison to the existing facility (16% in electricity, 87 % in district heating)
- About $20,000 per year savings through free cooling, thus reducing cooling costs

These values set the goals for the engineering design consultants Kulle & Hofstetter, TGA Consulting, Munich.

Neuperlach Hospital as Prototype

Ultimately, the choice was made in favor of the RAERS offer from

Konvekta, particularly because the performance of the system at the Munich-Neuperlach Municipal Hospital far exceeded expectations. At that time, Konvekta was the first and only manufacturer offering remote online system monitoring as well as performance verification. The hospital operating staff was very surprised by the effectiveness of the controller to operate the system efficiently and how little interaction it required from their technicians.
The advantages of this “black box” strategy became apparent very quickly because the continuously recorded utilization and energy recovery ratios of the system were above 90% which exceeded the guaranteed value of 74%. The heat recovery system controller functions independently, only requiring attention when system malfunctions occur which result in error messages.

From the point of view of the building designer and operator, the following factors contribute to the sustainably high efficiency of the heat recovery system:

- The tuning of the system according to the actual requirement.
- The system-view of the manufacturer, including computer simulation.
- Control of the system by the automated heat recovery system controller, including auto-reporting, automatic malfunction notification, and malfunction analysis data.
- The manufacturer’s one year operating responsibility/guarantee to monitor, fine-tune and optimize of the system

Conclusion

RAERS from the 1970’s and 1980’s no longer comply with the present-day requirements or expectations.

Existing ventilation and air-conditioning systems can be upgraded with high-efficiency RAERS, and their efficiency ratio (as the Bogenhausen Hospital example shows) can reach 90% while retaining and utilizing existing components such as ductwork and piping.
It is imperative for high-performance energy recovery systems to be designed as an integral system applying simulation software that uses heating/cooling load data to calculate optimal heat exchanger output.

To maintain a high performing system, efficiencies must be continually calculated, monitored, and adjusted by an automated controller. The controller must also be capable of immediate failure notification and analysis.

Further information
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