Low-Energy Water-Based Air-conditioning system

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1. SYNOPSIS

Energy and cost-efficiency of water-based air-conditioning system was improved by using free cooling and low-energy technologies and developing a new highly integrated room element.

2. INTRODUCTION

Previous studies have shown that the cooling beam system was the lowest cost alternative for office building air-conditioning systems, when individual control and good indoor air quality was required. However, additional work was required to improve the energy-efficiency of the system.

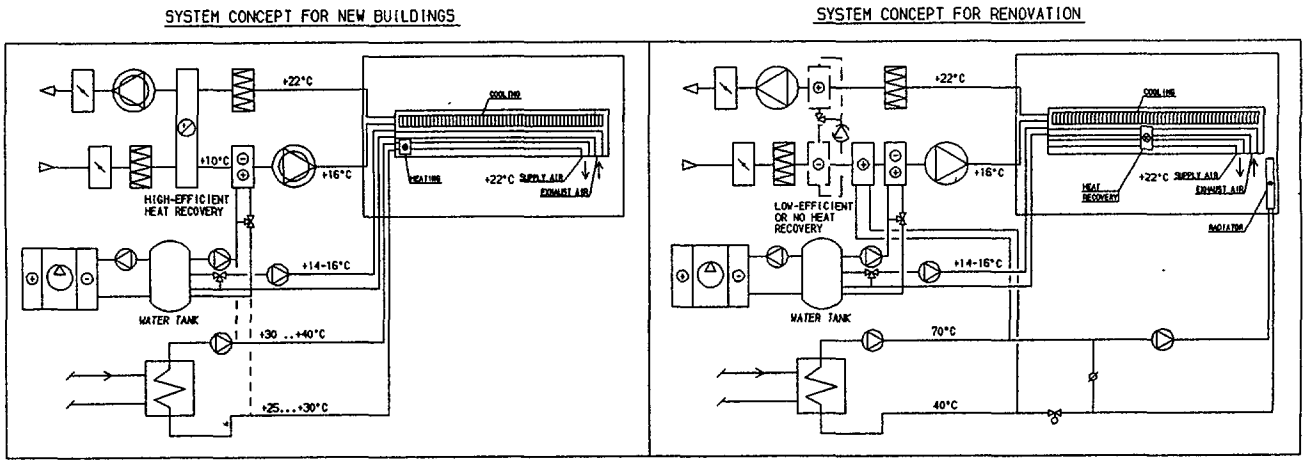
There was need for developing new low-energy room elements for this system. Depending on the building and system requirements it's possible to integrate both supply and exhaust air distribution, cooling, heating or heat recovery in the room elements.

3. SYSTEM DESCRIPTION

In developing of a new water-based air-conditioning system, a goal was set to improve energy and cost-efficiency by using free cooling and low-energy technologies.

Cost reduction and system simplification was achieved by providing for the typically separate air handling unit's heating, cooling and free cooling heat exchanger functions using a single coil. Primary system diagrams both for new buildings and renovation are presented in Figure 1.

Figure 1. Principle system concept both for new buildings and renovation



The system concept for new buildings is particularly suitable for low-energy buildings, which have special windows (U-value less than 1 W/m²K in Scandinavian type of weather). In this case the heating can be integrated into the room device and we can abandon separate radiators without the fear of window draught. The air-conditioning unit is equipped with an efficient heat recovery unit (about 75%). The required heating system water temperature is lower

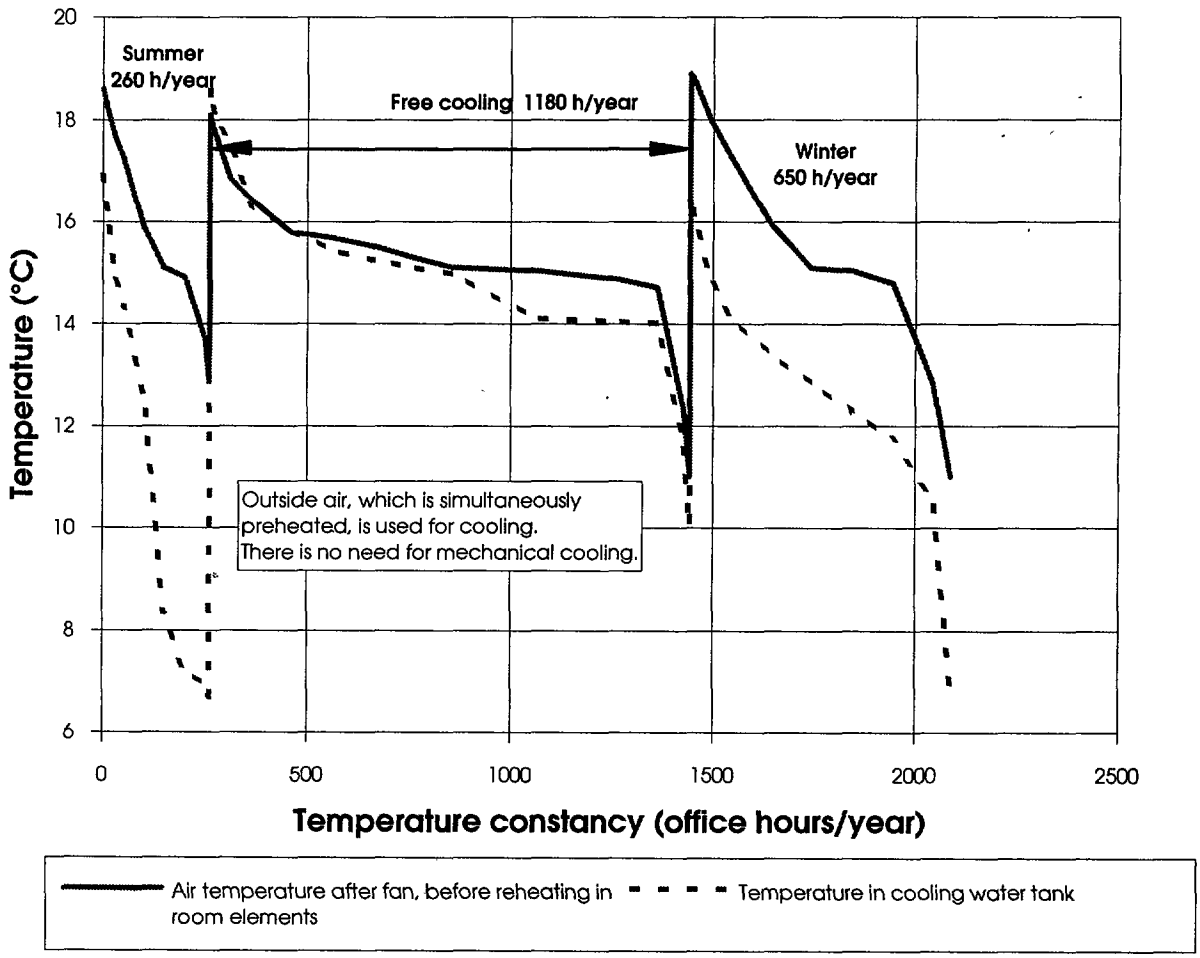
than for standard hydronic heating systems, which makes it possible to use municipal heating system return water at lower cost.

The system concept for renovation can be applied to existing buildings, in which there is an air-conditioning unit equipped with a heating coil and possibly a cooling coil and heat recovery unit. If the centralized heat recovery unit's efficiency is low or there is none, it is possible to save energy by integrating heat recovery into a room unit. Heat is produced by using existing radiators. The existing heating coil is only used in extremely cold weather.

4. TECHNICAL-ECONOMICAL ANALYSES

The operational performance of the low-energy system was first investigated for a typical building using computer modeling methods.

Figure 2. Temperatures in different operation sequences of the low-energy system.



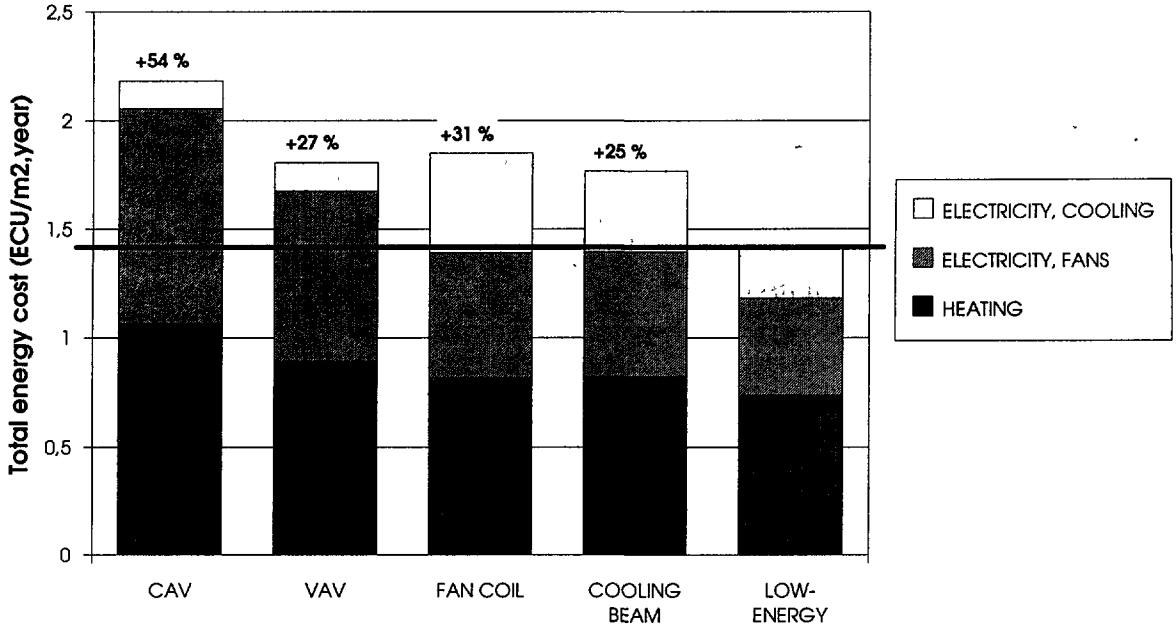
Central equipment's operation sequences and temperatures were determined over the whole year (Figure 2). The system operation was divided into three different modes. The annual hours of operation for each mode during normal office hours (weekdays 8:00-16:00) were as follows:

- Summer (260 h/year): Cooling energy is produced mechanically using a chiller.
- Free Cooling (1180 h/year): Outside air, which is simultaneously preheated, is used for cooling. There is no need for mechanical cooling.
- Winter (650 h/year): No cooling need.

Conventional air-conditioning system has to produce all the cooling energy mechanically with a chiller (water systems) or with a chiller and fan combination (air systems). By using the low-energy concept we need mechanical cooling energy only about 20 % of that time. In economic analyses, the low-energy system turned out to have lower investment and operation costs than other conventional air-conditioning systems equipped with individual room temperature control.

The low-energy system had the lowest energy costs of all the systems compared (Figure 3). The total energy costs were 35% lower than in constant air-flow system (CAV) and 20% lower than the most energy-efficient conventional air-conditioning system (cooling beam system).

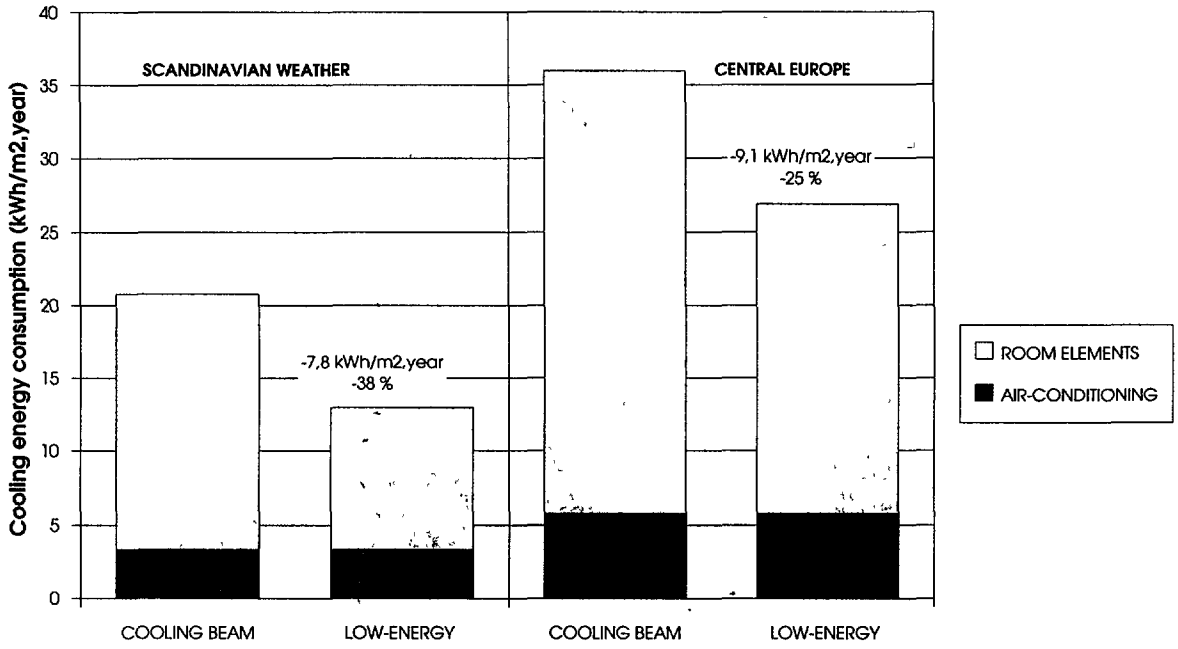
Figure 3. Energy cost in several conventional systems compared to the low-energy system.



In Scandinavian weather conditions, the free cooling function of the low-energy system reduces mechanical cooling energy consumption of room elements by nearly 50 %. The total cooling energy consumption (both AC-cooling coil and room elements) is reduced by 38 % compared to conventional cooling beam system (Figure 4).

In weather conditions typical in Central Europe, the total cooling energy consumption is reduced by 25 %. The actual energy savings potential is, however, higher in milder Central Europe climate than in the Scandinavian climate (9,1 kWh/m2,year vs. 7,8 kWh/m2,year).

Figure 4. Cooling energy consumption in a typical office building, conventional cooling beam system compared to the low-energy system. Calculations made both for Scandinavia (Helsinki) and for Central Europe (Stuttgart).



5. CONCLUSIONS

The new low-energy air-conditioning system concept offers:

- Good indoor air quality and individual control
- Available for both new buildings and renovation
- Up to 50% cooling energy savings
- Cost reduction and system simplification.

6. REFERENCES

Laine, T., and J. Pekkinen. 1995. "Low-energy, water-based air conditioning system". CADDET energy efficiency newsletter, no.1, pp. 26-28. Centre of the Analysis and Dissemination of Demonstrated Energy Technologies, Sittard.