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Efficient Interaction Between Energy Demand Surplus Heat, Cooling and Thermal Storage

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Abstract

The purpose of the research was to examine the savings potential and verify how to reduce the energy consumption in new hospitals by about 50%. Our results are also very relevant in other buildings complex with surplus heating, cooling and thermal storage.

Conversion and utilization of surplus heat sources represent well known technologies and are under constant development. In large building complexes there is a potential for coordinated production, storage, and distribution of energy. Heat pump, chiller and thermal storage technologies enable re-use of surplus heat/cool energy throughout the year. Energy supply and demand are typically modelled with separate tools and timescales.

Through our study new methods are developed for operation of interacting simulating models. These methods provide tools to step into optimization of combinations of integrated energy systems. The main issues focus on hydraulic water flow and storage systems as a basis. The layout is important not only with regards to utilize the energy quality, i.e. the temperature. In addition, control strategies are shown to have a highly relevant impact on the possible savings. Some details of new hydraulic layout and control design will be described and discussed in the paper. Both in combination with heating, cooling and storage system.

Our research indicates that it is possible to save between 20-50% of the energy consumption with optimizing the technical installations in Oslo area.

Another benefit of integrated thermal modelling is to reduce the risk of permafrost in ground source heat pump installations. This risk is relevant for large buildings in northern Norway, at annual mean temperatures are below 0°C.

This paper shows how integrated simulation and design can be used to avoid permafrost.

Keywords: Heating; cooling; thermal storage; technical solutions; energy savings

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1. Introduction

Buildings account for about 40 % of national energy consumption, and hospitals represent about 6 % of the total energy consumption in public buildings in Norway. Hospitals are the building category with the highest specific energy consumption. A large university hospital uses twice as much energy per square meter compared to commercial buildings. Large university hospitals recently built in Norway have annual energy consumption between 300-400 kWh/m2. New national building codes will soon require “passive house” standard for all new hospitals in Norway, and soon after that for retrofitted hospitals as well.

A breakdown of energy consumption in a typical large hospital is shown in Figure 1. The "Other" category in this Figure represents electricity consumption by medical and office equipment.

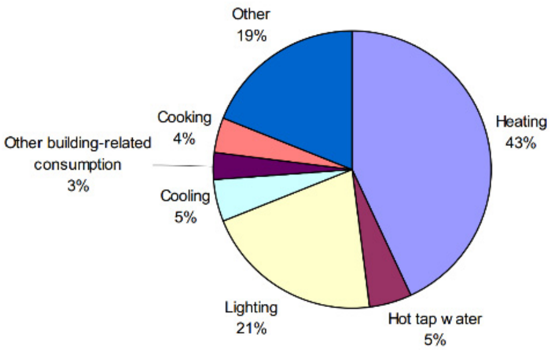

Figure 1. Breakdown of the energy flows in a large hospital

Within each of these categories of energy consumption are thermal energy streams which may be combined and re-used. Our research used interacting simulation models in new ways for integrating and optimizing these different combinations of thermal energy streams.

Surplus heat/cool in large hospitals might be created from internal loads like equipment, lighting systems, irradiance, related to occupancy and transferred by refrigeration or ventilation systems. The potential for energy interaction in these buildings is dependent on the available surplus heat/cool source. For building types, such as hospitals, where the need for heating and cooling are high and not necessarily matching the surplus heat and cool production, thermal storage is the most common technology together with use of heatpump / refrigerating machine.

Research on **thermal storage solutions** for hospitals so far mainly focused on the storage system and not considered the total energy system. We have analysed different temperature levels for supply and return heating water system as a function of outdoor temperature, different temperature levels for supply and return for cooling system and also design parameters for geothermal storage area. System efficiency is reduced by neglect of the interdependence between the subsystems.

Through the simulations and modelling we find that using the water twice, or serial connection for heating solutions, we can optimize the use of heatpump and reduce the energy consumption significantly. High design temperature for ventilation cooling coil and local fan coils can optimize the borehole specification.