Aalto University
School of Engineering

Dissertation Release 07.12.2021

Simulation applications to optimise energy performance & costs

Title of the dissertation	Simulation of advance thermal processes in buildings to optimise energy performance and costs.
Contents of the dissertation	This study concentrates on methodologies and practical solutions to improve energy performance in indoor ice rink arenas and increase buildings' energy flexibility to reduce their energy costs. The objectives of the study are as follows: 1) to investigate how the temperature gradient impacts the heat load towards the ice pad and evaluate the effects of various air handling unit (AHU) layouts on energy consumption, particularly at the cooling coil section; 2) to develop a simplified calculation methodology/tool based on a steady-state analysis in order to roughly calculate the energy demands/costs and primary energy in such arenas; 3) to develop a price-based control approach for reducing the energy costs of a residential building equipped with an electric heater, a geothermal heat pump, a solar thermal collector and a thermal storage unit; and 4) to develop a qualitative control method based on both varying electricity prices and the predicted outdoor weather data. The building performance simulation programs, IDA Indoor Climate and Energy (IDA-ICE) and Transient System Simulation (TRNSYS), were mainly conducted to obtain the results. Feld measurements were also implemented to validate the simulation models of ice rink arenas. The results reveal that ice rink refrigeration energy demand can be considerably decreased if the indoor temperature gradient approaches 1°C/m. To achieve this gradient, properly located and zoned air distribution solutions are proposed. Cooling and dehumidification energy demands reduced remarkably in the studied ice rink by 59.5% just by changing the location of the cooling coil in AHU. The applicability of the developed calculator is verified with reasonable accuracy in computing yearly energy costs, refrigeration and space heating demands and with a moderately higher deviation in cooling/dehumidification demands where a steady-state analysis is prone to considerable inaccuracy. According to the results of the price-based control method, the yearly cost of electricity can decrease considerably: in the studied case, by up to 11.6% by effectively shifting the loads, particularly during cold seasons. The qualitative control method reduces energy costs by 12.2%, which are further decreased by increasing the thermal storage capacity. Generally, the load-shifting concept can be applied as a potential benefit in any building.
Field of the dissertation	Energy performance in buildings
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Time of the defence	17 December 2021 at 12:00.
Place of the defence	Takka room, Dipoli, also remotely via Zoom: Link https//aalto.zoom.us/j/68812184033,
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The dissertation is publicly displayed online 10 days before the defense at https://aaltodoc.aalto.fi/doc_public/eonly/riiputus/