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ScienceDirect

Energy Procedia 132 (2017) 39–44

Energy Procedia

www.elsevier.com/locate/procedia

11th Nordic Symposium on Building Physics, NSB2017, 11-14 June 2017, Trondheim, Norway

# Thermal mass and energy recovery utilization for peak load reduction

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**Abstract**

Highly energy performing buildings need cost effective solutions which can deliver specified indoor climate and energy performance targets. In this study temperature variation of indoor climate category II according to EN 15251 standard is applied with the aim to allow free floating temperatures in this range to activate internal thermal mass of walls. Main hypotheses are that interior thermal mass of enough thick concrete layers can enable utilization of solar and internal gains resulting in significantly reduced peak loads for both heating and cooling, and reduced overall energy need. In this study, dynamic energy simulations are conducted to identify optimal solutions for a planned experimental building. Impact of energy recovery system on annual heating/cooling need and interior thermal mass on cooling design load are studied. Proposed energy recovery system consists of a piping layer installed into internal layer of a wall or floor structure and coupled with storage tank via piping and circulation pump. This system operates only when specified temperature differences exist that is expected to store excess room heat or cool within accepted indoor temperature range and to distribute it into other building zones. Modelling is performed in dynamic whole year simulation environment IDA-ICE, where a simplified two-zone model of a single-family house along with energy recovery system are modelled. Zones envelope and interior structures are modelled with finite difference wall/floor model accounting for thermal capacitances of structures material layers and exposure to solar radiation passing through detailed window model. Model of a piping layer connected to finite difference wall or floor structure computes heat transfer using logarithmic temperature difference. Rest of the energy utilization system is modelled using IDA-ICE standard model library components. Results reveal that interior thermal mass has significant impact on peak loads and energy need reductions. Modelled energy recovery system is capable of significantly reducing heating need as long as high system flow is maintained.


Peer-review under responsibility of the organizing committee of the 11th Nordic Symposium on Building Physics.

*Keywords:* thermal mass; IDA-ICE; energy recovery; heating need reduction; cooling load reduction

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10.1016/j.egypro.2017.09.628

## 1. Introduction

As European Parliament directive 2010/31/EU [1] requires all new buildings built to comply with nearly zero energy building requirements (nZEB) by the end of 2020, cost effective solutions for reduction of heating and cooling need to maintain the indoor climate within EN 15251 standard [2] category II are needed. A known passive way to reduce building cooling demand and peak cooling load is to include additional thermal mass in the building structures [3]. The goal of this study was to assess the impact of conventional envelope structure thermal mass on annual cooling need and design cooling load of a single-family house in climate of Warsaw, Poland. Additionally, to utilize solar and internal gains and provide an excess heat/cold transport between zones of the building an energy recovery system can be applied [4]. Energy recovery system consists of a storage tank connected via piping and circulation pump to a piping layer installed into internal layer of a wall or floor structure. The second goal of this study was to model prior mentioned system and assess its performance.

Results of annual energy simulations applying two conventional wall structures with equivalent U-values and different thermal masses and their impact on annual cooling need and design load are presented. Performance of energy recovery system in heating and cooling need reduction are assessed with a parametric study and presented in graphical form, actual energy recovery system sizing is performed and proposals for system seasonal coefficient of performance (SCOP) improvements are conferred.

## 2. Methods

The modelling was performed in building climate and energy performance simulation environment IDA-ICE at advanced level interface, where user can manually edit connections between model components, edit and log model specific parameters, observe models code.

### 2.1. Numerical study description

Two simplify the geometry of a single-family house, a two-zone model presented on Fig. 1 was generated based on principles of sizing the windows of the South façade to 60% of external wall that is facing South and North façade windows to 15% of North zone floor area. To comply with common design practices, an external shade with length of 1.8 m was added to South and applied in all simulated cases.

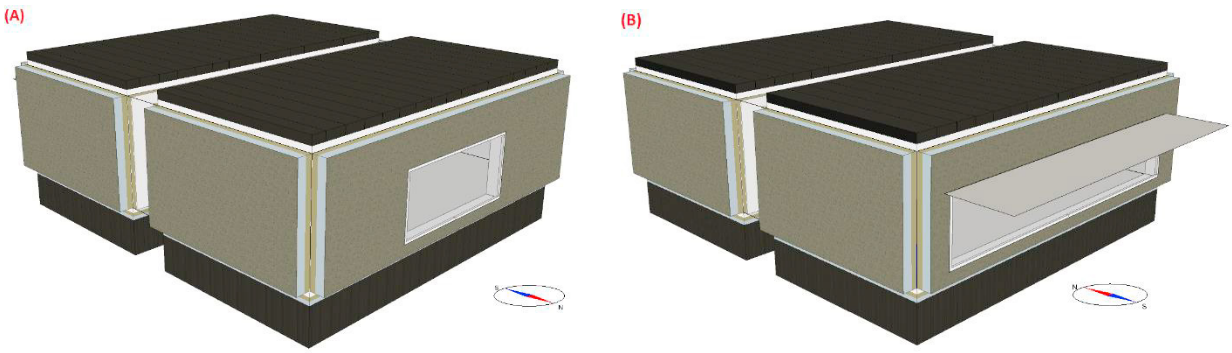


Fig. 1. (a) North-East façade of two-zone model; (b) South-West façade of two-zone model.

North and South zones lack connection between each other and interior wall in each zone is adiabatic. The reason for previous condition is to avoid the heat transfer between zones for more accurate reflectance of energy recovery system performance. Zone windows are oriented exactly facing North and South. The floor area of zones is equivalent and equal to 50 m$^2$ each. Ambient boundary conditions regarding local weather data were described in Warsawa-Okecie ASHRAE IWEC2 climate file [5] and applied in the simulation. Indoor air temperature setpoints correspond to indoor climate category II according to EN 15251 [2] standard i.e. heating setpoint 21 °C and cooling setpoint 25