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# Energy saving and indoor climate effects of an added glazed facade to a brick wall building: Case study

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ABSTRACT

This study is focused on the energy saving and indoor climate analysis of the renovation of a 1930's brick-walled building in the moderately cold climatic conditions of Malmö in southern Sweden. Three facades of the building were glassed in and the ventilation system was renewed. The purpose of this study was to investigate the effect the added glazing would have on the building's energy demand and indoor climate. Measurements were taken on site and were used as the input for computational studies performed with the help of IDA Indoor Climate and Energy software (IDA-ICE).

The study showed that the heating energy demand was reduced after the glazing installation by between 5.6% and 25.3%. In addition, the mean annual temperature difference between the cavity space and the outside air was from 5.2 °C to 11.4 °C higher, depending on the design. A number of different design options were explored for the winter and also summer case-studies, as it was apparent that adding glazing decreased the level of comfort in the building's indoor environment in summer time. This problem could be solved by increasing the cavity air flow or adding new solar shading to the front or back of the glazing.



**Contents**



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## 1. Introduction

In order to save energy in existing buildings different measures can be taken e.g. building technical solutions, such as adding insulation to the building envelope, and building services solutions, such as adding heat recovery to the ventilation system. Other solutions may also be applied if special requirements are to be met, cultural heritage considerations could be one example. In these situations, the façade can be protected with a transparent glass layer construction added in front of the façade.

In this study, an old hospital area in Malmo was being renovated. The renovation had a sustainable profile. One of the houses was a small flat brick building which was first intended to be externally insulated. However, the exterior was not allowed to be altered too much so instead it was decided to construct a glazing on the façade, creating an air cavity between the old brick wall and the glazing. This technical measure was chosen as it improves the insulation of the building envelope by reducing the heat transmission losses through the exterior walls, and it warms the building by capturing the solar energy absorbed by the brick wall and could also be used for pre-heating of the ventilation air. In line with its strategy of achieving sustainable solutions, the city of Malmö planned and installed an extensive amount of measurement sensors at various points in the building to enable evaluation and control of the technical solution. The study of the energy demand and indoor climate performance of the building was the main objective of this study, and the intention was to estimate the energy needed for different design solutions, and their effects on the indoor climate. The objectives for this study can therefore be specified as being to:

1. Investigate how effective the chosen renovation method was regarding energy and thermal comfort.
2. Build an IDA-ICE model and use measurements from the real building to validate that the IDA-ICE model behaves in a qualitatively realistic way compared to the renovated building.
3. Investigate other possible renovation choices with the IDA-ICE model for both winter and summer conditions.

Measurements were made on site and were used as inputs for computational studies performed with the help of IDA Indoor Climate and Energy software (IDA-ICE) 4.6.2. Software validation was carried out by comparing the field measurement results to the simulations during one week in winter, one in summer and one in spring. After creating a valid model, a total of 63 whole-year simulations were conducted in order to analyse the impact of different glazing and ventilation modes on the building's energy demand. In addition, the building's indoor temperatures in summer were also analyzed. The heating energy-saving studies (winter mode) included different amounts of glazing (one, two and three glazed façades), various glazing solutions (single, double and triple glazing) and two air inlet modes (through the cavity space or directly from outside). The summer conditions studies (cavity cooling mode) included evaluation of the cavity window ventilation, the cavity mechanical exhaust ventilation (FF2-fan) and supply by the ground duct system (TF1-fan) as well as internal and external blinds for the cavity glazing. Calibration studies were made without tenants in residence, and a simulation analysis was performed using the standardized living habits of tenants, which was the only difference between the analyses of the calibration and the simulation. The building is structurally homogeneous, like a typical brick-walled building in Sweden, which makes it possible to apply the results to similar buildings.

## 2. Background

In general, a double skin façade (DSF) can be defined as multiple layer skin construction [1] and is considered to be a promising energy conservation measure for buildings [2]. New multi-story office buildings are sometimes built with a DSF [3]. Solutions applied to residential buildings such as [4–6] are clearly less commonly studied, and those studies which have been carried out have mainly focused on multi-story buildings. DSFs have rarely been studied as a method of protecting the façades of architecturally significant buildings [7], especially with regard to protecting smaller buildings, as in [8].

Typically, a DSF is composed of an external and an internal layer, as well as the cavity space, which acts as a buffer and can be used for controlled ventilation and solar protection [9]. Typically, the inner and outer layers are glazed structures [10]. The inner skin consists of double- or triple-pane glass filled with air, argon or krypton, while the external skin is single glazing [3]. Controllable shading systems have been typically located inside the cavity [11] and cavity depths have varied from 0.2 to over 2.0 m [3]. There have been few field-measurements or simulations where the internal skin consists of material with a high thermal mass [12]. Measures for adding glazing to protect old facades while they are being renovated [7] have also received little attention. Energy savings in a cooling-dominated climate are mostly connected to glazing solutions with a low solar factor and low U-value in order to minimize the cooling load of the building [13]. Conversely, in a heating-dominated climate, a high solar factor is recommended – especially in the situation where the added cavity is also utilised to pre-heat the ventilation air [14], because this allows the highest available amount of passive solar heat gain.

Ventilation of the cavity could be natural, forced or mixed. It is also possible to integrate it with the naturally- or mechanically-driven ventilation system inside the building. The results of Ref. [7] shows that a DSF which is connected to naturally-ventilated buildings is a valuable renovation solution and may reduce the energy demand by up to 12%. The work of [15] also supports the fact that DSFs with natural ventilation minimize the use of cooling energy and enhance thermal comfort. Stec and van Paassen [16] have underlined the importance of integrating a DSF into the building's ventilation unit. Saelens et al. [17] suggest a changeable system whose settings can be adjusted according to the climatic conditions, if traditional glazing solutions with external shading deemed to be inadequate. This means, for example, that it should be possible to change the system's mode of operation between