Overheating reduction in a house with balanced ventilation and postcooling

Bart Cremers

Zehnder Group Zwolle
Lingenstraat 2
8028 PM Zwolle, The Netherlands
bart.cremers@zehndergroup.com

ABSTRACT

The outdoor climate is changing and the airtightness and insulation levels of residential buildings are improving. During the warmer season this can lead to overheating problems, especially when the house is situated in urban areas. In order to reduce overheating problems, ventilative cooling can be used to keep the indoor conditions at a comfortable level. Natural ventilation is not always a feasible solution, for the risk of burglary, and when the outdoor temperatures are not suitable for cooling the house, for instance in urban heat islands.
This document describes the monitored performance of a ventilation system in a nearly zero energy building in Modena, Italy. The house is ventilated with a balanced ventilation system in combination with a water/air heat exchanger in the supply air from the ventilation unit, hereafter named postconditioning system. The water in the exchanger comes from a heat pump, activated by a room thermostat that defines whether there is a request for cooling or heating. In summer, the system cools and dehumidifies the fresh air (postcooling) and in winter the system heats the fresh air (postheating). The resulting cooling and heating is the only conditioning means in the house, there is no other cooling or heating system installed in the house.
The monitored performance is shown with example weeks in summer, autumn and winter. In these weeks the functional modes of balanced ventilation and postconditioning are shown, together with the resulting temperatures in the relevant air streams. The modes of indoor heat recovery, indoor heat extraction and outdoor heat rejection, in combination with postcooling or postheating, can clearly be observed. The overall performance during a 7 month period is shown in a correlation graph where extract, supply and postconditioned supply temperatures are given as a function of outdoor temperature.
The postconditioning system does not only show the cooling effect in a sensible way (temperature decrease of supply air) but also in a latent way (humidity decrease of supply air). This is indicated by the monitored temperatures when the water temperature in the postconditioning system is dropping below the dew point of the fresh air in summer. The resulting condensation on the postconditioning exchanger decreases the absolute humidity of the fresh air, which adds to the comfort of the fresh air supply even further.
The ventilative cooling as a result of indoor heat extraction, outdoor heat rejection, in combination with postcooling is discussed looking at the resulting extract air temperatures (indication of indoor temperatures). It is shown how the overheating problem in this house is reduced by the mechanical ventilation system, even when summer outdoor air temperature and humidity are higher than indoors. Both the hygiene in terms of guaranteed fresh air, and the comfortable supply air temperatures, make this ventilation system a comfortable, and energy efficient solution for all seasons of the year.

KEYWORDS

Nearly zero energy house, balanced ventilation, overheating reduction, postcooling

1 INTRODUCTION

The outdoor climate is changing towards more extreme temperatures and the airtightness and insulation levels of residential buildings are improving. During the warmer season this can lead to overheating problems, especially when the house is situated in urban areas. In order to reduce overheating problems, postcooling of ventilation air can be used to keep the indoor conditions at a comfortable level. Natural ventilation is not always a feasible solution, for the risk of burglary, and when the outdoor temperatures are not suitable for cooling the house, for instance in urban heat islands.

2 MONITORING SET-UP

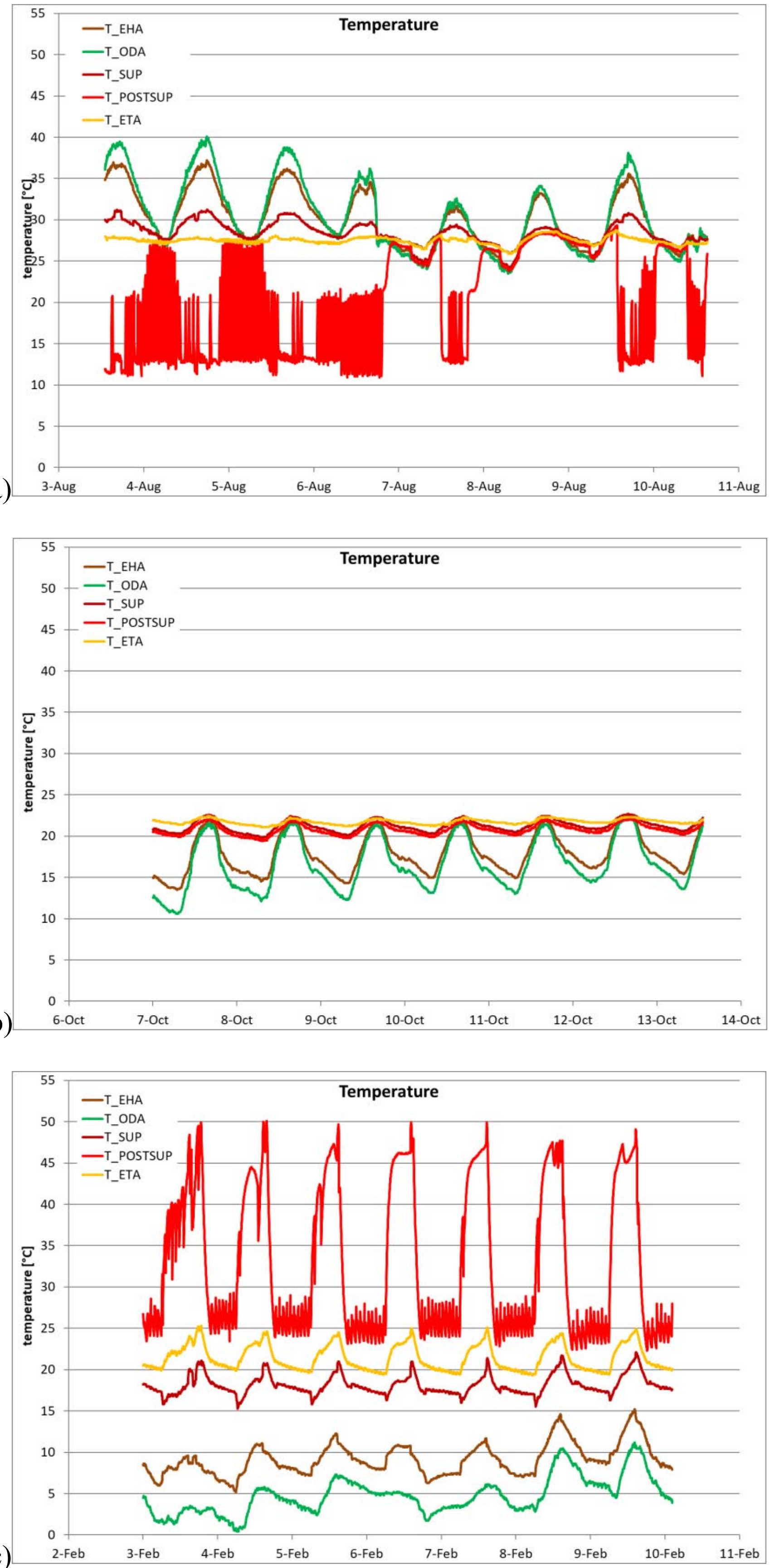
This document describes the monitored performance of a ventilation system in a nearly zero energy building in Formigine, near Modena, Italy (fig. 1). The house is ventilated with a balanced ventilation system (type ComfoAir Q600) equipped with enthalpy exchanger. The flow rates in the fan positions low, middle and high are set at 180, 250 and 420 m^3/h.

Figure 1: Nearly zero energy house in Modena, Italy

The balanced ventilation system is equipped with a water/air heat exchanger in the supply air of the ventilation unit, hereafter named postconditioning system. The water in the postconditioning system comes from a 4 kW heat pump, activated by a room thermostat that defines whether there is a request for cooling or heating. In summer, the system cools and dehumidifies the fresh air (postcooling) and in winter the system heats the fresh air (postheating). The resulting cooling and heating is the only conditioning means in the house, there is no other cooling or heating system installed in the house.

3 MONITORING RESULTS

The monitored performance is shown in figure 2 with example weeks in summer, autumn and winter. In these weeks the functional modes of balanced ventilation and postconditioning are shown, together with the resulting temperatures in the relevant air streams. In summer, the outdoor heat (temperatures up to 40°C) is rejected because of the cold recovery from the colder indoor air of 27°C. The ventilation air is postcooled during daytime to a supply temperature between 11°C and 20°C, when requested by the room thermostat.
In autumn the indoor temperature of 22°C is fairly constant because the indoor heat is recovered. In this example week the outdoor temperatures between 10°C and 15 °C lead to supply temperatures of the fresh air of about 20 °C.
In wintertime the outdoor temperature in the example week are between 0°C and 10°C. The indoor heat is recovered and postheated to a supply air temperature of about 25 at nighttime and up to 50°C temperature during daytime.



a)

b)

c)

Figure 2: Air temperatures in exhaust air (brown), outdoor air, (green), supply air (dark red), postsupply air (light red) and extract air (yellow) for an example summer week (a), autumn week (b) and winter week (c).

The overall performance during a 7 month period is shown in a correlation graph where extract, supply and postsupply temperatures are given as a function of outdoor temperature. In this graph the function modes can be observed for the whole ventilation system. Heat recovery with possible postheating in the cold season and heat rejection with possible postcooling in the warm season. In the intermediate season there is no postconditioning and the heat is either recovered (bypass not active) or removed from the house (bypass activated). The extract air temperatures in the correlation graph show that in summer, the extract air temperatures (indicative for indoor air temperature) are kept below 27 °C because of the postcooling effect.

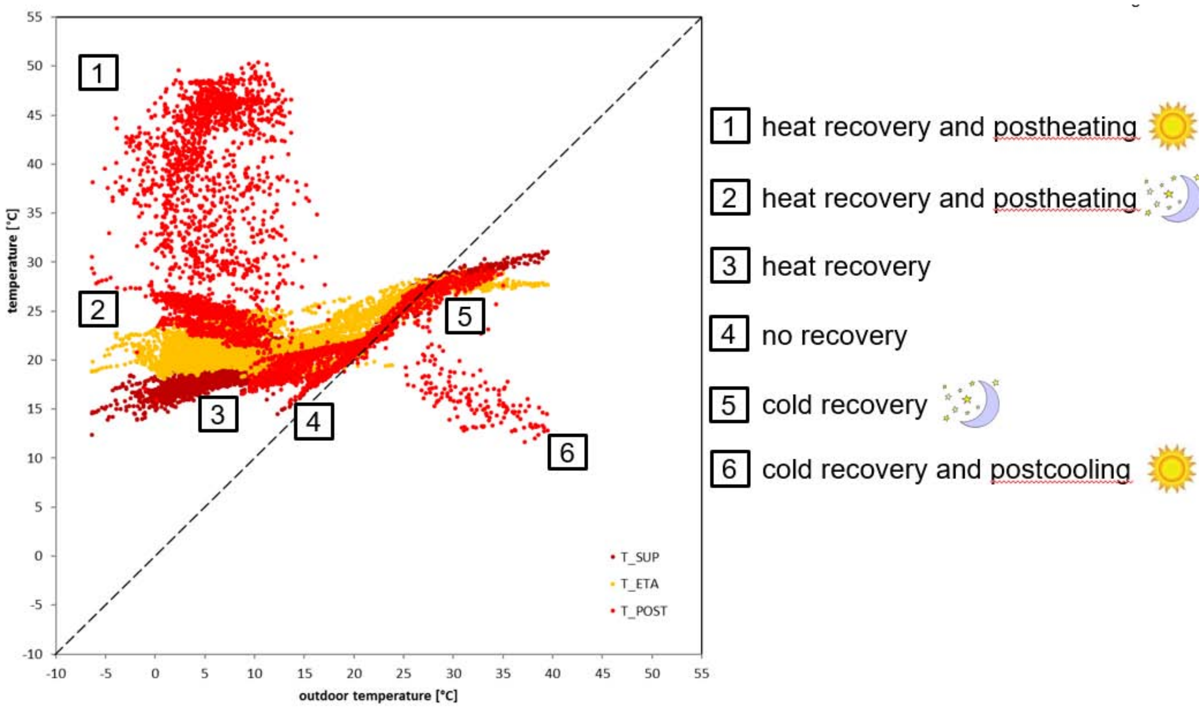


Figure 3: Hourly averages of extract air temperature (yellow), supply air temperature (dark red) and postsupply air temperature (light red) as a function of outdoor air temperature.

The postconditioning system does not only give a cooling effect in a sensible way (temperature decrease of supply air) but also in a latent way (humidity decrease of supply air). This is indicated in fig. 4 by the monitored temperatures.
For a period of one summer month, the water temperature is estimated by the measured postsupply air temperature (for a well dimensioned heat exchanger in the postconditioning system this estimation is valid). The dewpoint of the air before it enters the postconditioning is calculated from the supply air temperature and supply air humidity as measured in the balanced ventilation unit.
It can be observed in fig. 4 that with an active postcooling, the water temperature is dropping below the dew point of the fresh air in summer. As a result of this, the condensation on the postconditioning exchanger is expected to lower the absolute humidity in the supplied fresh air, which adds to the comfort of the fresh air supply even further.

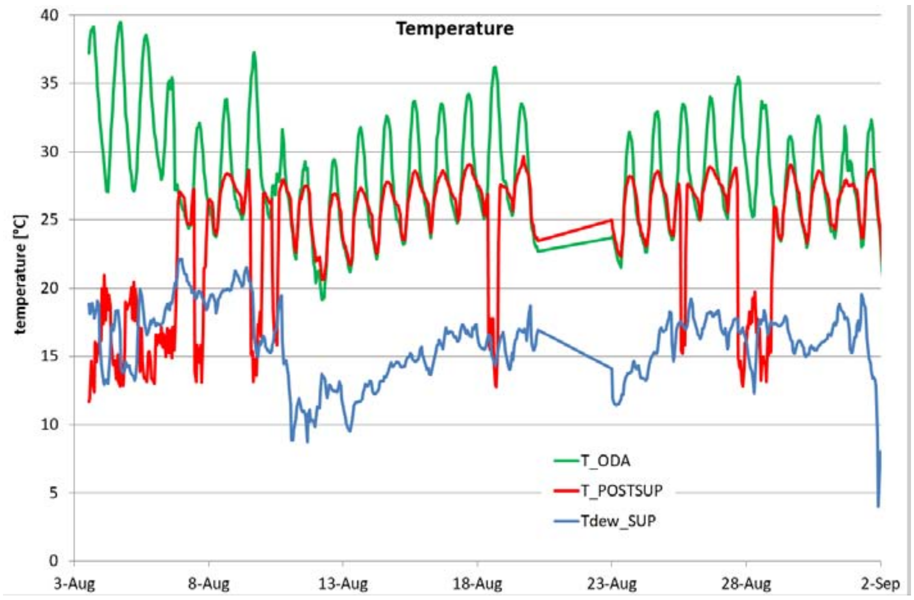


Figure 4: Monitored values during a summer month of outdoor air temperature (green), postsupply air temperature (light red) and dewpoint of the supply air (blue).

4 CONCLUSIONS

The ventilative cooling as a result of indoor heat extraction (activated bypass) and outdoor heat rejection (bypass not activated) reduce the overheating effect in a nearly zero energy house in summer. In combination with postcooling with chilled water from a heat pump, it is shown how the overheating problem in this house is reduced by the mechanical ventilation system, even when summer outdoor air temperature and humidity are higher than indoors. The results show that the extract air temperatures are about 27°C for outdoor air temperatures as high as 41°C.
Both the hygiene in terms of guaranteed fresh air, and the comfortable supply air temperatures, make this ventilation system a comfortable, and energy efficient solution for all seasons of the year.