# Energy saving potential of a ventilated window and solar energy storage system for residential buildings


## Summary

A ventilated window with integrated solar energy storage can guarantee good indoor climate and energy saving by storing and utilizing solar energy to preheat room ventilation in the heating season. Moreover, residential buldings constructed or renovated recently experience overheating during the summer period. The energy storage can also be used to pre-cool room ventilation during summer. A phase change material is used in the energy storage to ensure high energy storage capacity at near room temperatures.

The energy saving potential of the system is studied by modelling of a renovated apartment and a sustainable passive house located in a Danish climate.

For the apartment the results show that application of a ventilated window will save 13.8% of the electricity use for the heat pump during summer, and 24.4% during winter, compared to applocation of standard window(SW) with fresh air intake through the façade. For the combined ventilated window and energy storage system the energy saving is 45.9% during summer, and 34.5% during winter.

For the house the energy saving applying the ventilated window is 10.8% during summer, and 6.8% during winter, and for the combined ventilated window and energy storage system the energy saving is 23.1% during summer, and 21.1% during winter


## System description

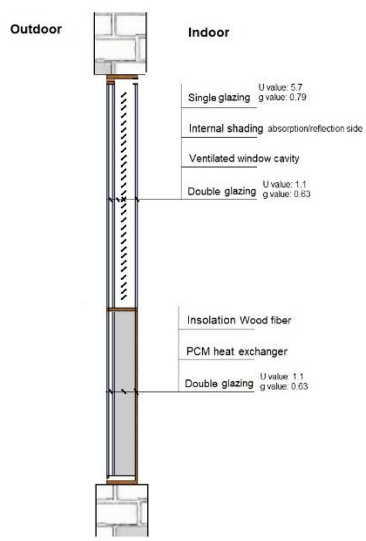


Figure 1. The sketch of the ventilated window and energy storage system.

In the ventilated window and energy storage system (Figure 1) the intake air will pass through the system before it is supplied to the room. Figures 2 and 3 show the working principle of the system during summer and winter respectively. Figure 4 shows the working principle of the ventilated window in both summer and winter. For the application of a standard window solution, a simple facade vent is used for supplying the same ventilation airflow rate.

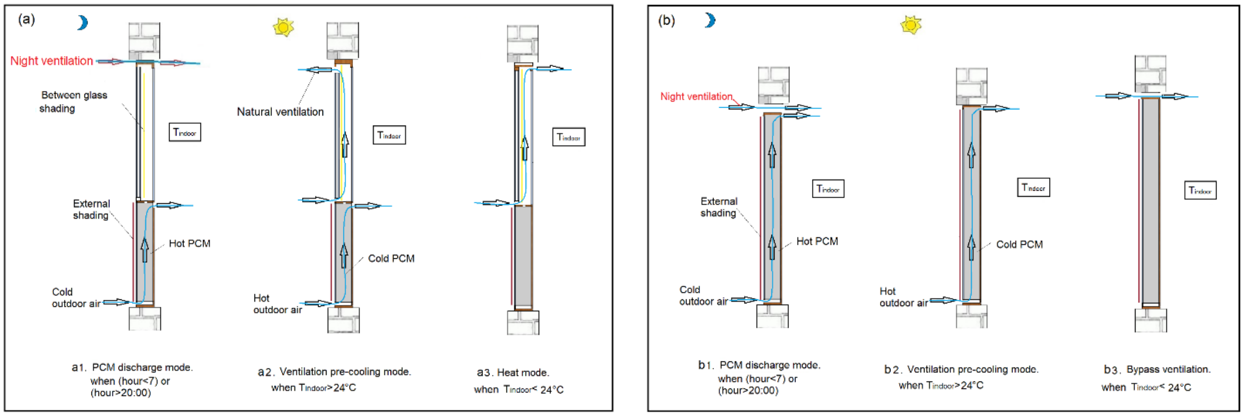


**Figure 2.** The working principle of (a) the combined ventilated window and energy storage systen and (b) the energy storage during summer.

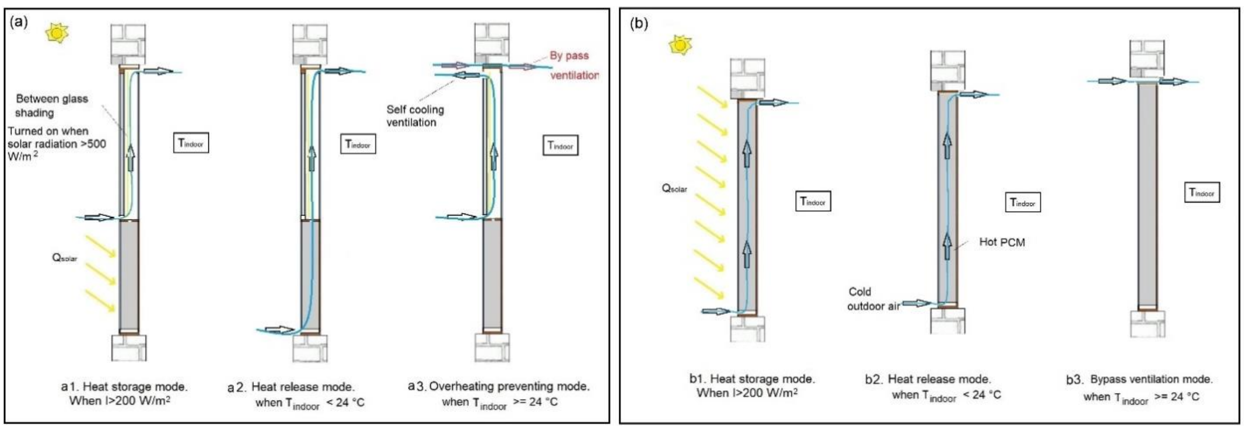


**Figure 3.** The working principle of (a) the combined ventilated window and energy storage systen and (b) the energy storage during winter.

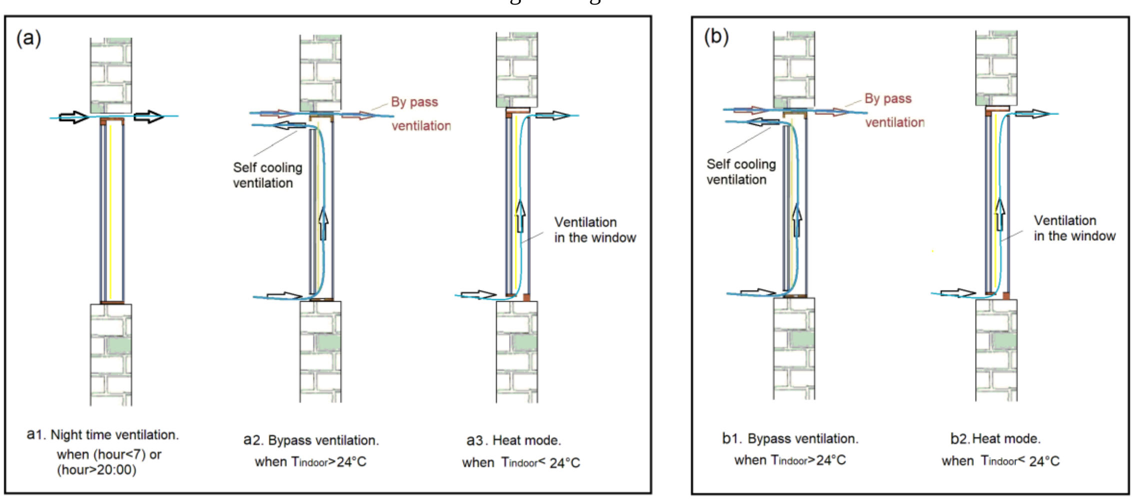


**Figure 4.** The working principle of the ventilated window (a) during summer and (b) during winter.

# Energy saving potential

## Building 1: Apartment

A 3-room apartment in the second floor of a 3-floor building is firstly studied, as shown in Figure 5. The apartment has 2 external facades facing northwest and southeast, and 2 internal walls adjacent to the other apartments. The energy use is compared in three cases: A) with four ventilated windows with integrated energy storages, B) with four ventilated windows and C) with four standard windows and fresh air intake through façade vents.

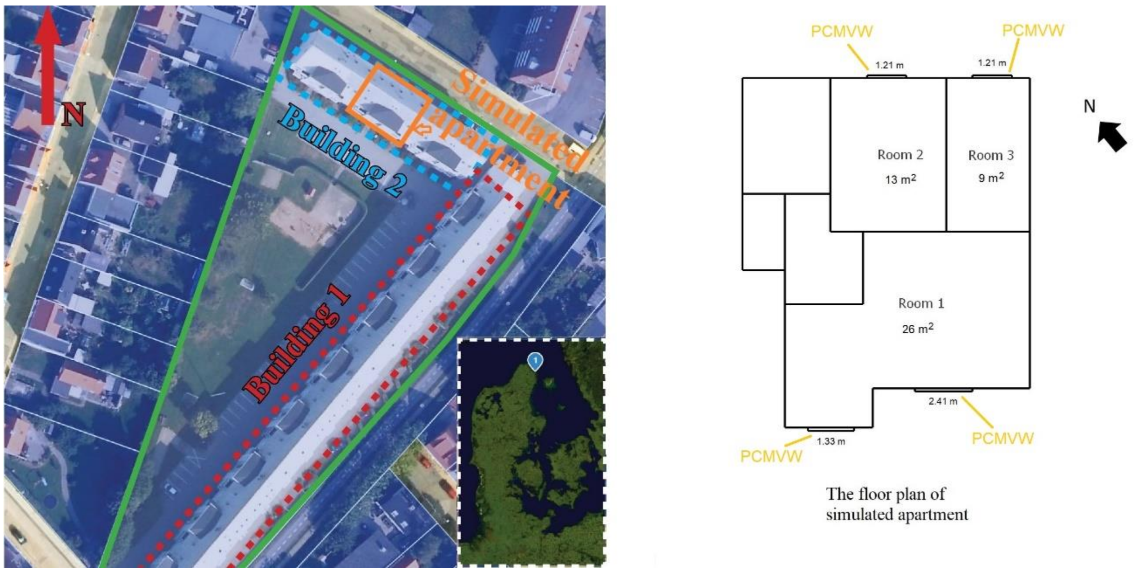


**Figure 5.** Plan view of the Danish demonstration site and the apartment used for the investigation.

Figures 6 and 7 show the influence of ventilation airflow rate on the energy use and energy saving potential of the apartment in summer and winter, respectively. In summer, the heat pump electricity use decreases and then increases with increasing airflow rate. The heat pump has the minimum electricity use when the ventilation airflow rate is 0.7 $h^{-1}$ for all the 3 models. Under this ventilation airflow rate, the energy saving potential of the ventilated window and energy storage system is 45.9%, and for the ventilated window it is 13.8% compared to the solution with a standard window. In winter, the heat pump electricity increases with increasing airflow rate. The heat pump has minimum electricity use when the ventilation airflow rate is 0.4 $h^{-1}$ for all the 3 models and the energy saving potential is 34.5% for the ventilated window and energy storage system, while for the ventilated window it is 24.4% compared to a solution with standard windows.

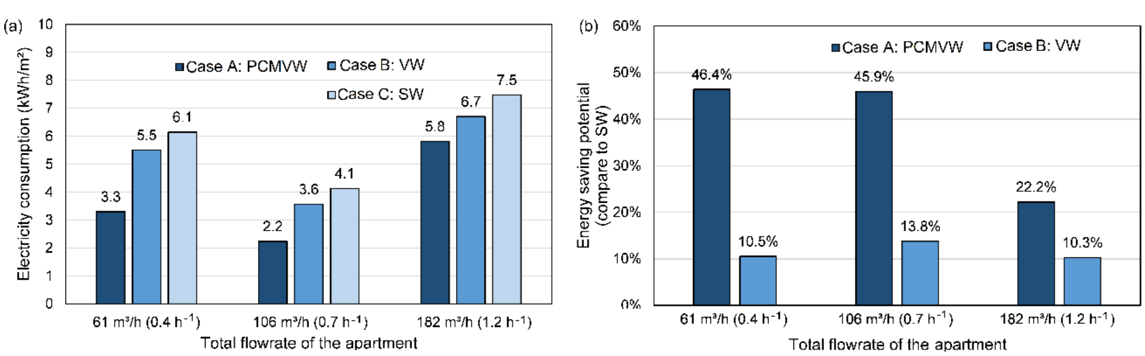

**Figure 6.** The modeling results of the apartment under different ventilation airflow rates during summer. (a) The heat pump electricity energy use; (b) The energy saving potential.

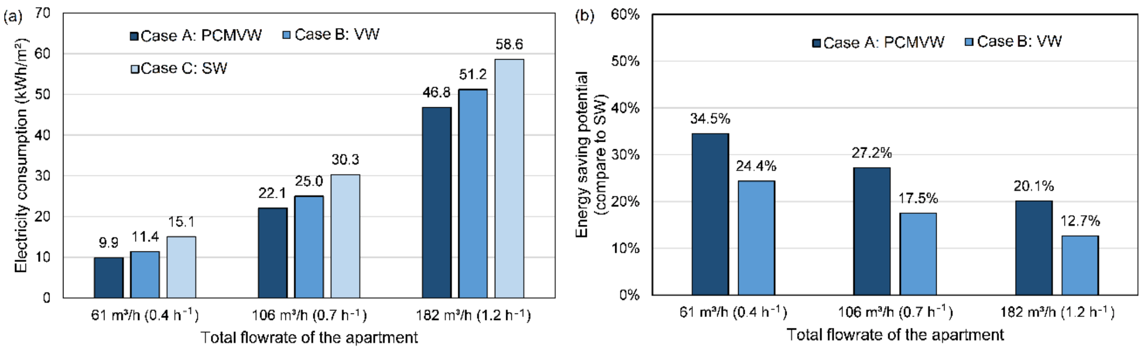


**Figure 7.** The modeling results of the apartment under different ventilation airflow rates during winter. (a) The heat pump electricity energy use; (b) The energy saving potential.

## Building 2: Family house

The layout of the single family house is shown in Figure 8. The house is built using sustainable straw panel walls and foundations without thermal bridges. The energy use is compared in three situations: A) With each bedroom equipped with a ventilated window and energy storage system and the living room with one ventilated window and energy storage system and two energy storage systems to add extra thermal storage to the room, B) with four ventilated windows in the building and C) with four standard windows in the building.

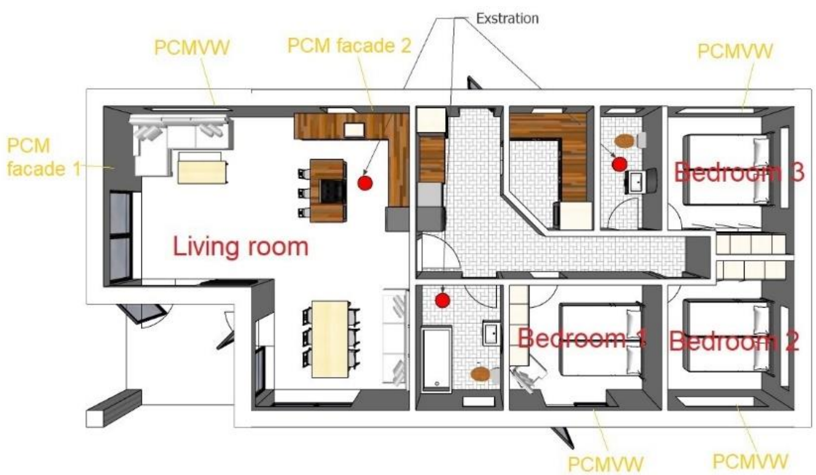


**Figure 8.** Layout if the single family house

Figure 9 and 10 show the influence of ventilation airflow rate on the energy consumption and energy saving potential of the house in summer and winter respectively. In summer, the heat pump electricity consumption decreases and then increases along the increase of the airflow rate. The heat pump has the minimum electricity consumption when the ventilation airflow rate is 1.2 $h^{-1}$ for all the 3 models. Under this ventilation airflow rate, the energy saving percentage of the PCMVW is 23.1%, and the energy saving percentage of the VW is 10.8% compare to SW. In winter, the heat pump electricity consumption increases along the increase of the airflow rate. The heat pump has the minimum electricity consumption when the ventilation airflow rate is 0.4 $h^{-1}$ for all the 3 models. Under this ventilation airflow rate, the energy saving percentage of the PCMVW is 21.1%, and the energy saving percentage of the VW is 6.8% compare to SW.

The PCMVW and VW has more energy saving percentage in the apartment than in the house, for the reason that the apartment has less energgg demand than the house, due to its adiabatic adjacent walls.

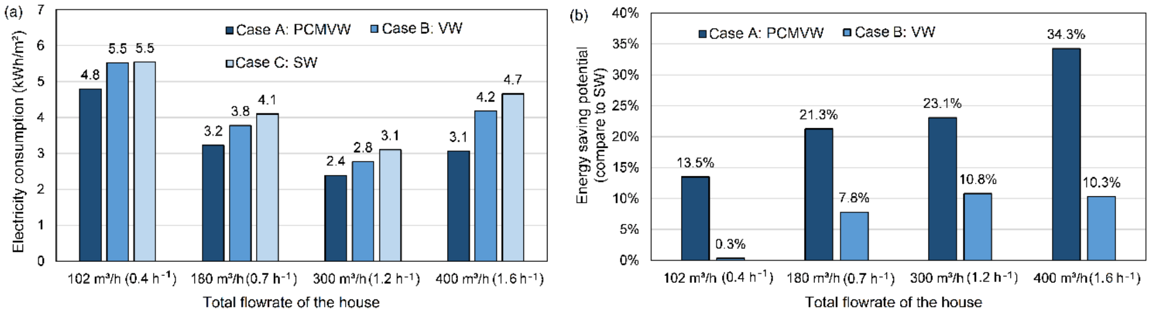


**Figure 9.** The modeling results of the house under different ventilation airflow rates during summer. (a) The heat pump electricity energy use; (b) The energy saving potential.

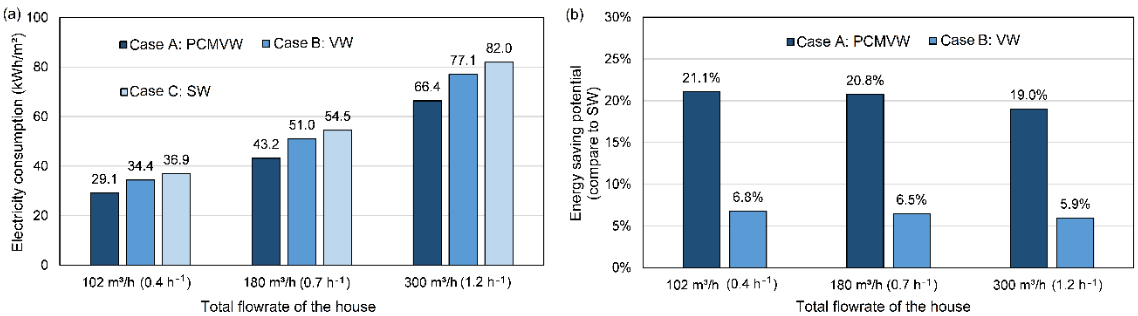


**Figure 10.** The modeling results of the house under different ventilation airflow rates during winter. (a) The heat pump electricity energy use; (b) The energy saving potential.