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Effect of solar ventilation on thermal improvement and energy efficiency of buildings using phase change materials.

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Abstract- The effects of carbon fuel consumption on the environment have stimulated development of a 'net-zero' energy measurement in buildings envelope for sustainable buildings a net-zero energy is key to reducing energy use and saving money .For several decades, low-income citizens in Moroccan cities have been suffering from thermal inequality, energy poverty and thermal comfort constraints.The article presents the integrated the mechanical solar ventilation and phase change materials into the building envelope using the simulation software of the thermal behavior in dynamic regime TRNSYS, this project aims at the design of a single-family house whose energy balance over one year of operation. In particular when the air temperature is close to the melting temperature 22 °C . A global building model consisting of a building envelope modeled and simulated in TRNSYS and EnergyPlus and the modeled exchanger Mechanic solar ventilation air/PCM fan system is simulated under climate (CASABLANCA NOUSSEUR).The energy consumption related to the specific uses of electricity is taken into account in the annual energy balance. The results show that the Mechanical solar ventilation with the phase change materials (PCM+MSV) reduces the operating temperature of the house significantly and relative humidity and maintain the demand energy from HVAC system. Indeed, the Mechanical solar ventilation has decreased its average operating temperature by about 2.7°C-3°C and created the fresh and comfort space.

Keywords: Phase change material ; Mechanical solar ventilation ; Desingbuilder ; Trnsys; Comfort;Thermal performance; Energy efficiency.

The house studied in this project (unoccupied) is located in (CASABLANCA NOUASSEUR). Its total surface is 110 m2 and it rises on: a basement, a first floor, the main facade faces south.

I. Introduction

Recently, concerns about the thermal load of buildings have received increased attention, as buildings are the largest consumers of energy in most countries. Numerous investigations have shown that many problems are due to the indoor environment of inhabited premises. In the 1980's the first insulated buildings were built according to thermal regulations. As a result, the number of parasitic air intakes has decreased. On the other hand, there was an increase in the rate of pollutants inside the buildings (e.g.: paint, varnish, cleaning products,). This is why it was necessary to remedy this problem by imposing a ventilation of the inhabited parts. A house must be well ventilated. We often forget this, because we want to insulate. But insulation does not exclude a healthy air! Today, there are adapted solutions that allow you to take advantage of ventilation for the house while saving energy. Heat recovery is an approach for HVAC (heating, ventilation and air conditioning) [7], which protects the environment and reduces the energy used in buildings. It improves energy efficiency and reduces energy consumption, as energy losses due to ventilation account for up to 50% of total energy losses in buildings. It is important to ensure adequate air circulation for moisture reduction when renovating a house, it is essential to ensure that the air can circulate and that there is sufficient ventilation to allow for moisture regulation in the home. The fight against mold also contributes to the comfort of the home. When insulating exterior woodwork is installed, it must have an integrated ventilation slot in all rooms where there is no mechanical solar ventilation such as MSV. Several solutions are available to ensure air quality in your home .The air purifier is designed to clean the air inside your home. However, it is important to invest in a MSV, whether it is single flow or, better still, double flow. Both models ensure air renewal, but the double flow MSV allows to preheat the incoming air thanks to the action of the outgoing air, which makes it an ecological and economical solution. Today, there are other alternatives, which focus on ecology. The solar ventilation allows renewing the air of the habitat. Thanks to the sun's energy, this new air is also warm! The air is healthier! The MSV, is a device that automatically forces the extraction of air to ensure its renewal and its quality inside a home.

Energy losses in ventilation have a huge impact on energy consumption in buildings. In this work, the energy performance of a heat recovery wheel system equipped with an air handling unit was tested throughout the year, and the results were compared with the results of the system simulation using TRNSYS . An energy analysis is performed at the whole building level by Dynamic Thermal Simulation (DTS) [4], on TRNSYS[1],and DesignBuilder Software [2]. The researchers have performed an energy saving calculation using simulation. Often, the conventional approach cannot be done under different environmental conditions. Energy saving has been studied by several researchers under different climatic conditions. Jamil and al [12]. developed a TRNSYS [9]. model to simulate a desiccant dehumidifier. Experimental measurements were obtained and compared with the simulation results. The simulation results showed that the coefficient of performance of the system had a critical influence when the regeneration temperature and relative humidity were varied. Walling and al[13]. studied the improvement of the energy performance of a building using a heat pump . The heat pump system was simulated using TRNSYS[9]. They found that it is possible to increase the heat exchange rate of the air handling unit by coupling a heat pump to the air handling unit with a mechanical ventilation . Other studies have focused on the energy performance of a building using THE TRNSYS[9] simulation software, to calculate the payback period when an energy recovery system is implemented. López , al[14],by using TRNSYS[9], simulated an experimental opaque ventilated façade module, indicating that the opaque ventilated façade has potential to achieve free ventilation and air preheating and its performance could largely be dependent on the wind speed and direction, as well as the intensity of solar radiation. The main objective and novelty of this study was the development of a simulation model suitable for determining the energy consumption of solar ventilation systems. The simulated results were validated with the other experimental studies. The effects of ambient parameters, such as regeneration, temperature and relative humidity (RH), on the energy performance were investigated. The electrical energy consumption was calculated to obtain the impact on the electrical energy consumption of the MSV of electrical energy of the MSV.

II. Description and methodology:

The overall objective of the project is to improve the living conditions of the local population, through welfare and the fight against poverty and social inequalities. The specific objective is to set up a pilot unit using local building materials, with low environmental impact, provided with with organic phase change materials in order to study the improvement of the energy efficiency of residential energy efficiency of residential and tertiary buildings. The valorization of local materials represents a priority for this project. Indeed, the analysis of of the environmental performance and economic feasibility of these materials is an important new field of scientific research. scientific research. The benefits, the energy consumption and the environmental indicator for all stages of the life cycle of the PCM must be life cycle of the PCM must be evaluated in detail to configure an appropriate energy balance perspective of the material of the material's life cycle. Our research strategy aims to examine in detail the topic of PCM use as thermal energy storage materials for the building sector. The aim will therefore be to verify the feasibility and technical performance of PCM as a new way to stabilize the air temperature inside buildings. The study includes a modelling and numerical simulation to verify with experimental components. To carry out this project, a model will be developed by taking into account the physicochemical properties of the PCM to be integrated in the building envelope and the local climatic conditions in relation with the thermal comfort.The simulations will be done using the EnergyPlus and Trnsys calculation tools by studying a large parametric analysis to calibrate the proposed model. The modeling of this system is essential to define the specifications of the materials and to determine how th.ese PCMs can be integrated into the building the building envelope.

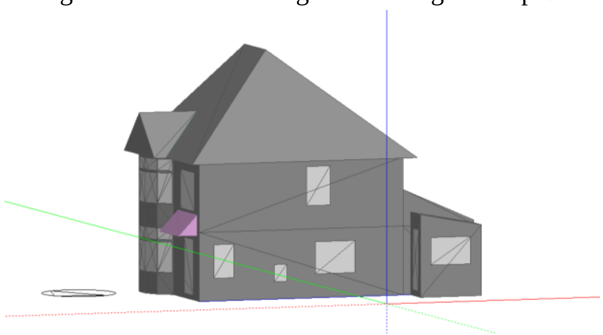


Fig.1 . 3D view

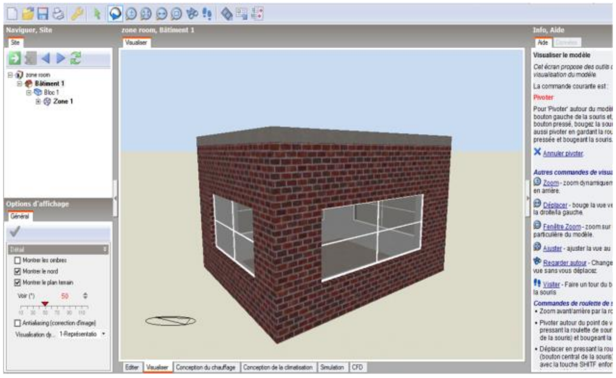


Fig.2 . 3D view of the zone .

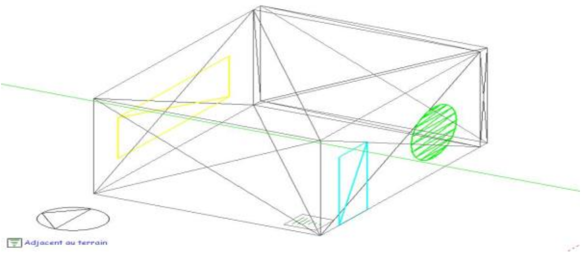


Fig.3 . 3D view of the area zone .

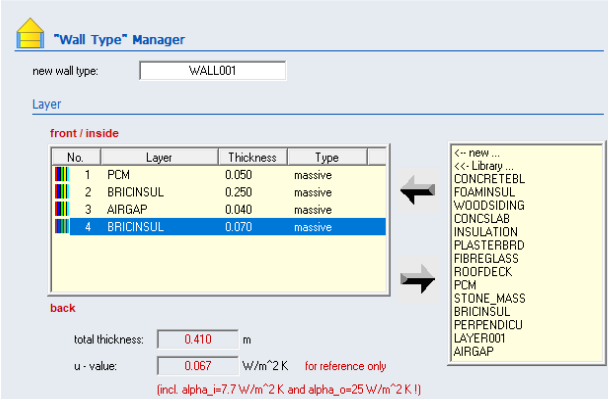


Fig.4. Parameters of the PCM wall in building envelope.

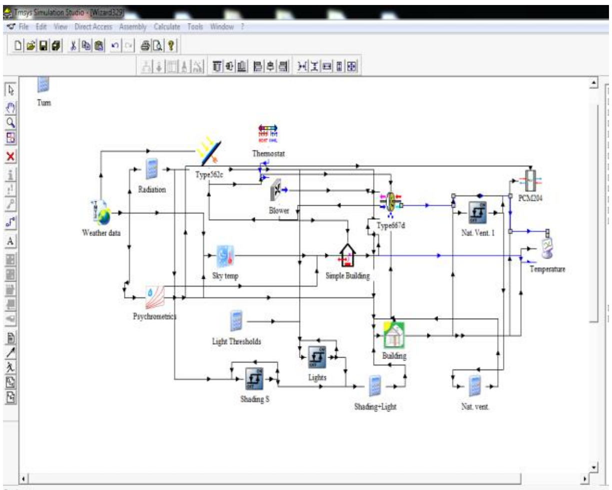


Fig.5.Representation of the building subsystem in the TRANSYS interface

Type 667 represents an air heating device that can be controlled either externally, or set to automatically try and attain a set point temperature. The furnace is bound by a heating capacity and an efficiency. Thermal losses from the furnace are based on the average air temperature. The outlet state of the air is determined by an enthalpy based energy balance that takes pressure effects into account. H in and H out refer to the enthalpy of air entering and exiting the furnace, respectively. Thermal loss calculations are made based on the average temperature of air in the furnace and $q\eta$ is the capacity of the furnace multiplied by its overall efficiency. In other words, $q\eta$ is the amount of energy actually transferred from the fuel to the air in the mechanic solar ventilation furnace.

$$\boldsymbol{H\ air\ out = H\ air\ out + \frac{q\eta}{m} + \frac{UA}{m}(T - Tair)}.$$

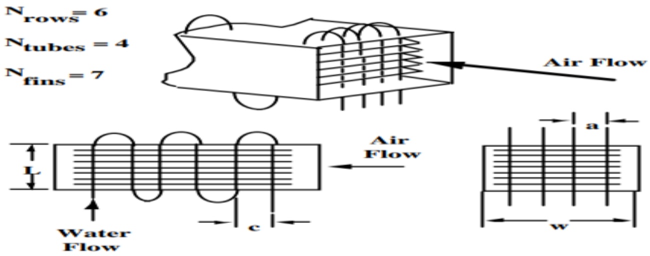


Fig.6.: Schematic And Cross-Sectional Views Of A ventilation

The convective flows shown in Figure 7 are defined by thefollowing equations:

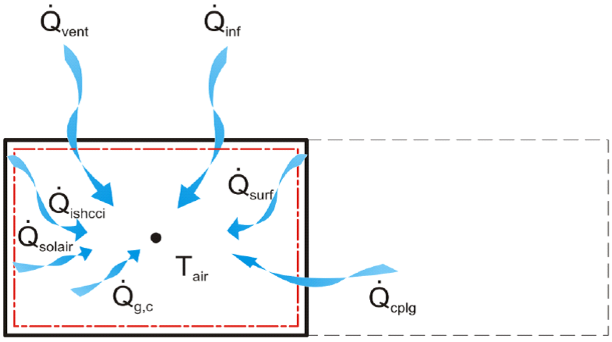


Fig. 7. Convective heat fluxes on an air node (TRNSY

Qi =Q surf,i+Q inf,i+Q

wind,i+Q g,c,i+Q cplg,i+Q solair,i+QSHCCI,

with : Q surf,i : Convective gains interior walls. *Q surf,i=Uw,i *Aw,i(Twall-Tair) .*

Q inf,i: Infiltration gains (airflow from the outside).*Q inf,i=V ρ Cp(Text,i-Tair)*

Q wind,i: Ventilationgains (airflow from a user-defined source, HVAC system).

Q wind,i=V ρ Cp(Tvent,i-Tair).

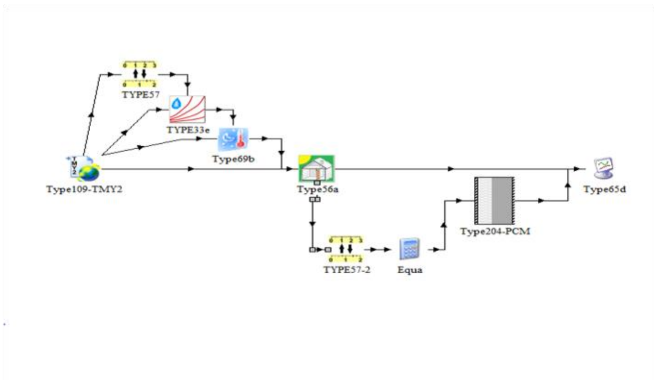


Figure .8. Simulation model inTRNSYS204.

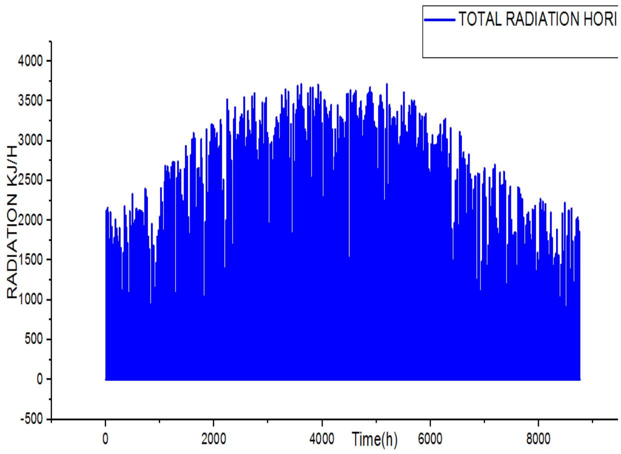
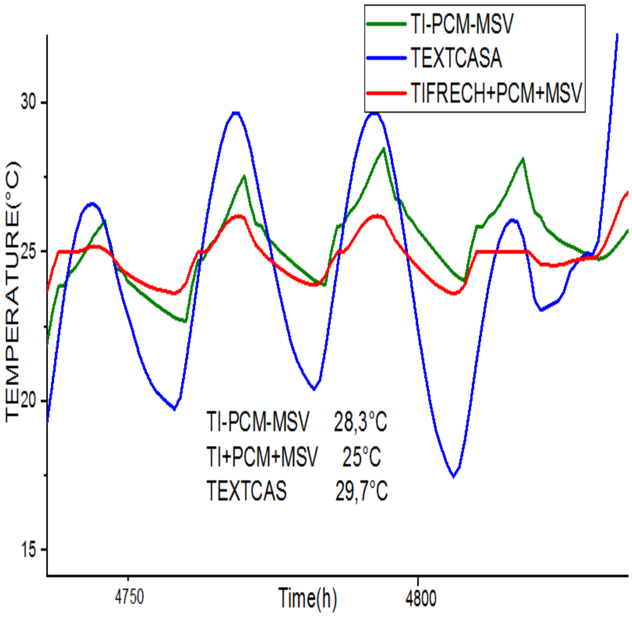


Figure. 9. Power produced by photovoltaic panels.



III.Results and discussion.

Fig. 10. Evolution of internal air temperature with(PCM+MSV) ,nwithout(PCM+MSV) and external temperature in summer.

Fig10shows the Evolution of external temperature (Casablanca nousseur) and internal air temperature with (PCM+MSV)and without(PCM+MSV)in summer into the building envelope. The results of the simulation show that the temperature of the outside air varies between 18 and 30 ° C. The internal air temperature without(PCM+MSV) varies between 24 and 28 ° C, the temperature with walls (PCM+MSV)has low values compared to that without(PCM+MSV), the temperature with(PCM+MSV) varies between 23°C and 25.6 ° C. It was found that the presence of phase change materials in the building envelope and the presence of MSV decreasing the air temperature by 3° C. The thermal model developed using TRNSYS can be considered adequate for the analysis of energy performance and thermal comfort of the apartment as well as for the design of energy-saving strategies in the considered climates**.**

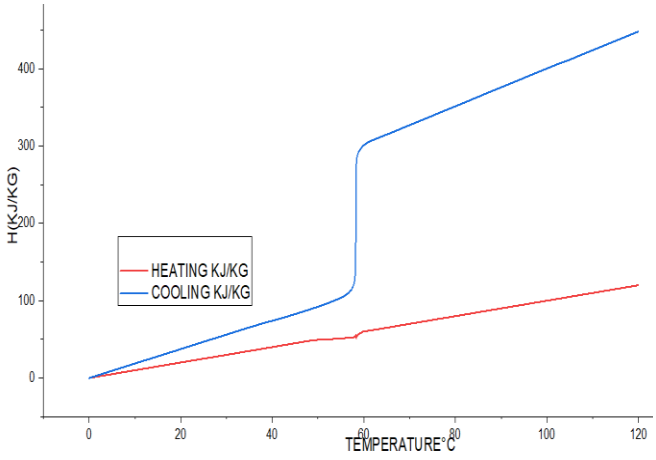


Fig. 11. Measured data with deferent entalphy.

For a single heating-up data file would be necessary.But to simulate also cooling-down a cooling curve has to by generated.For the area of phase change in the heating curve is cut-out and a cooling curve with subcooling is inserted .For low temperatures and in the phase change region the data are identical. For the high temperature range a line of best fit between 61.6 and 75.2 °C is used to extrapolate up to 120 °C.

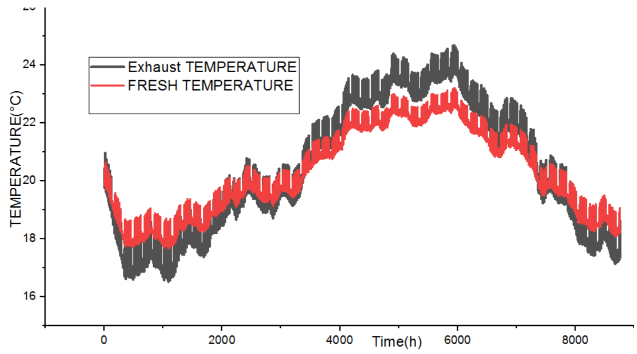


Figure .12. The fresh outlet and exhaust inlet around the heat .

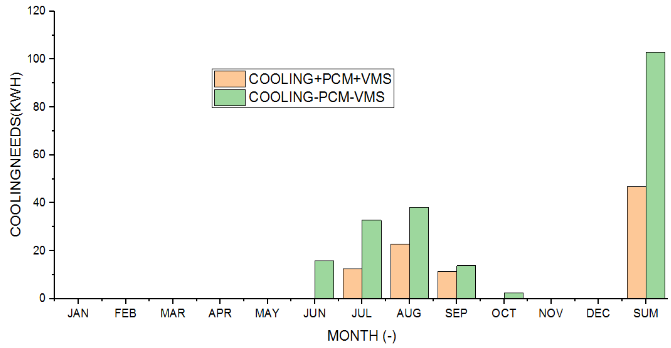


Fig.13.Monthly cooling consumption of air conditioning with(PCM+MSV) and without(PCM+MSV) **.**

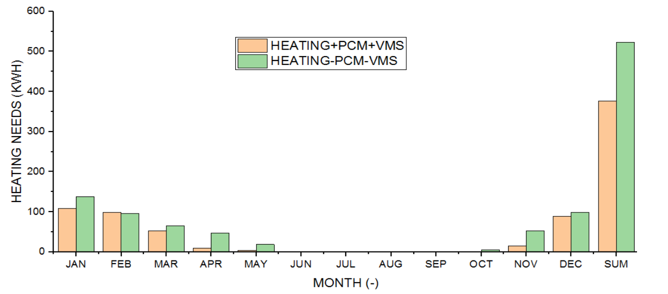


Fig. 14.Monthly heating consumption with (PCM+MSV) and without (PCM+MSV)

The comparison of heating and cooling requirements for the two SCENARIOS , shows that the building with (PCM+MSV) requires less energy for heating and cooling than the building without (PCM+MSV) During the winter period, January has the highest energy consumption during heating. The building without (PCM+MSV) consumes 140 kWh for heating, but the building with (PCM+MSV) consumes only 100kWh.The month of August has the highest consumption during the cooling season.The air conditioning energy consumption for the building with (PCM+MSV) in August was *24 KWH* slightly lower than that without (PCM+MSV)*52KWH.*

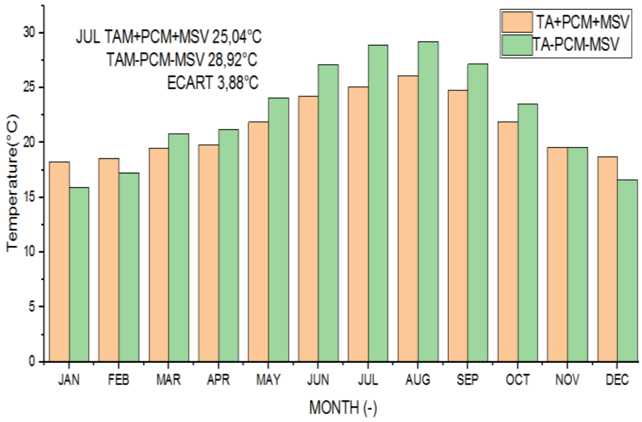


Fig. 15.Monthly evolution of the air temperature with(PCM+MSV)and without(PCM+MSV)

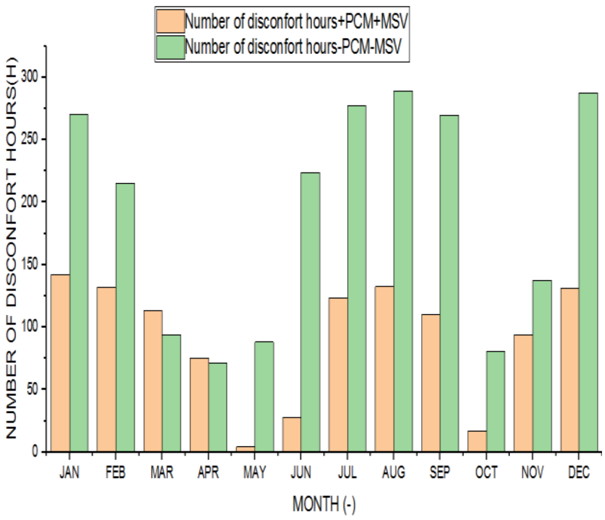


Fig.16 . Number of discomfort hours with(MSV+PCM)and without(MSV+PCM).

Figure 16 shows the maximum absolute difference between the temperatures simulated by the numerical model DesignBuilder V4 with (PCM +MSV) and without (MCP +MSV) in summer a (CASABLANCA NOUSSEUR), and the distribution of this difference. Overall, it is clear that the majority of the differences between the simulated temperatures with (PCM +MSV) and without (PCM+MSV) a difference of 3.88 ° *C.*

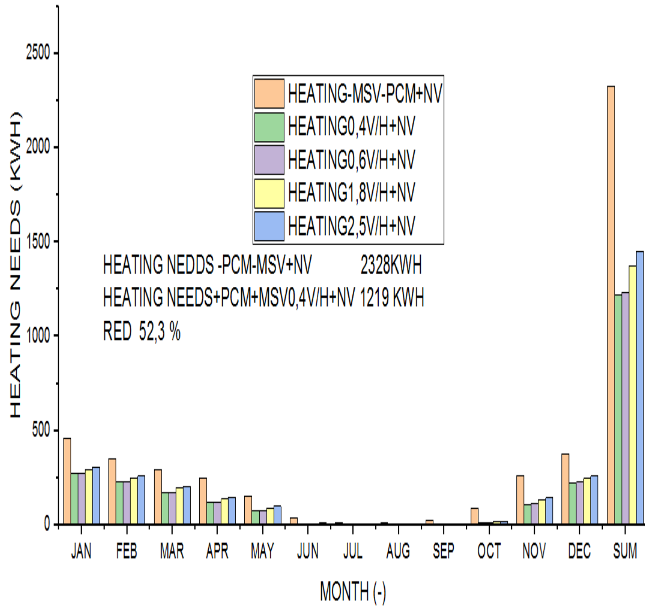


Fig. 17. Energy consumption for different amounts of solar ventilation in summer.

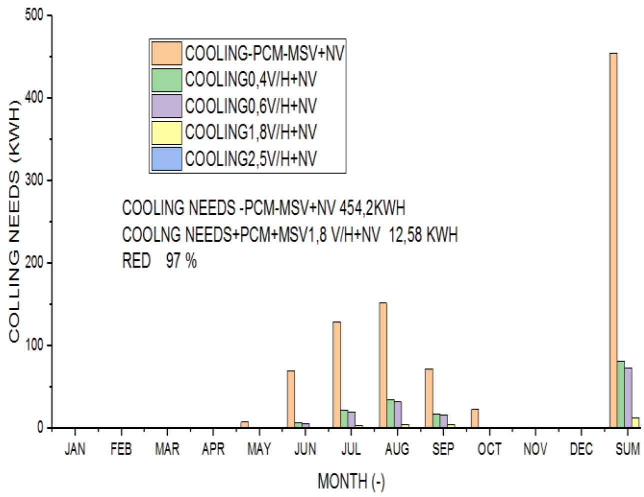


Fig. 18. Energy consumption for different amounts of solar ventilation in winter.

Figures 17, 18 show the effect of the amount of ventilation on the heating and cooling energy consumption for the climate zone (CASABLANCA NOUASSEUR). The cooling energy consumption decreases with increasing amount of solar ventilation. In general, the greater the amount of ventilation provided, the greater the effect of the PCM on energy savings. However, the effect of the amount of ventilation on energy consumption became insignificant when the ventilation was greater than 1.5 AC/h. The cooling energy consumption, ventilation energy consumption and total energy spent for different ventilation amounts in (97.23% reduction), and when decreasing the solar ventilation amount between 0.4AC/H and 1.3 AC/H the energy consumption decreased in winter (52.5% reduction). So we take between 0.4 and 1.3 AC/H in the heating period and between 1.3 and 2.2 AC/H in the cooling period. Which means that the amount of ventilation also played an important role in reducing energy consumption.

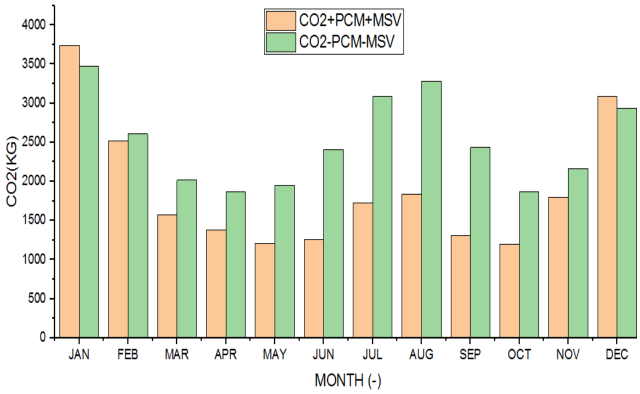


Fig.19.Monthly CO2 concentration with (PCM+MSV) and without (PCM+MSV)

The comparison of the CO2 concentration for the two SENARIOS, shows that the building with (PCM+MSV) requires less CO2 concentration than the building without (PCM+MSV). The annual sum of CO2 concentration with (PCM+MSV) reaches 22625 kg, has low values compared to the annual sum of CO2 concentration without (PCM+MSV) 31073 kg gains of 8448 kg of CO2 (Reduction of 27.19%). Thus, the CO2 concentration in a room of a given indoor environment remains essentially dependent on the CO2 concentration present in the outdoor air, on the intensity of the emissions of the CO2 sources present (e.g number of occupants and types of activities practiced by them in the said room) and on the air exchanges between this room and the other rooms of the building as well as with the outdoor environment, which can be modulated in particular by the natural, mechanical or hybrid ventilation . It should be noted that the processes likely to attenuate the concentrations of CO2 can also lead to the reduction of the concentrations of other gaseous or particulate contaminants of the indoor air.

IV.CONCLUSION

It is concluded that the efficiency of the PCM can be improved if the building can be properly ventilated to release some of the heat gains during the night. In particular when the air temperature is close to the melting temperature of the PCM 22 °C . A global building model consisting of a house modeled and simulated in TRNSYS and EnergyPlus and the modeled exchanger fan system Mechanic solar air/PCM is simulated under climate (CASABLANCA NOUSSEUR) . In this article, mechanical ventilation with solar energy is proposed according to different ventilation rates between 0.4 and 1.3 ACH in winter and 1.3 and 2.2 ACH in summer. In addition, the mechanical ventilation unit is powered by a solar photovoltaic system; if solar power is not available, the ventilation unit is connected to the national power grid. solar mechanical ventilation can also increase the airflow locally and improve heat transfer. Similarly, solar mechanical ventilation can be used to accelerate the heat release from the PCM at night and the thermal energy storage efficiency of the PCM can be significantly improved. It is believed that the application of PCM on the building envelope with cooling and environmentally friendly natural and solar ventilation can be one of the most effective measures to minimize indoor temperature fluctuations and mold and reduce building energy consumption and CO2 concentration.The results show that the Mechanic solar ventilation (MSV+PCM) reduces the operating temperature of the house significantly. Indeed, the ventilation has decreased its average operating temperature by about 1.6°C-2.3°C.and the analysis of this result shows the beneficial effect of the(MSV+PCM)on the energy saving of the building in the climate (CASABLANCA NOUASSEUR).and maintain the cost demand equipment about HVAC , optimum thermal performance energetic , control the exchange air flow with external and internal surface and also created the fresh and comfort space .

Acknowledgement:

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Conflict of Interest

The authors declare that there are no conflicts of interest.

Compliance with Ethical Standards:

This article does not contain any studies involving human or animal subjects.

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[8], HVAC system According to the requirements of ASHRAE 90.1-2010 Appendix G, the HVAC system in the base model depends on the building type.