Do we want high humidity recovery in our home?

Residential ventilation units are increasingly being equipped with heat exchangers. High efficiency sensible heat exchangers with efficiencies in excess of 90% are readily available and are being used in residential ventilation systems. Latent heat exchangers, that recover moisture as well as sensible energy, are starting to get a foothold on the market and can achieve latent efficiencies of 80%, while sacrificing some sensible efficiency.

From purely an energy perspective the high level of moisture recovery is of considerable interest due to the high energy capacity of the moisture in the air.

However, the question is whether the occupants and the indoor climate benefit from this high moisture recovery, or whether the extra moisture creates an ideal environment for microbes and pests?

1. A healthy and comfortable indoor climate

The way people experience comfort indoors is highly dependent on temperature, humidity and clean air which, in turn, are all interdependent.

Although modern central heating systems keep homes at a constant indoor temperature of approximately 20°C, they do not control humidity.

High levels of moisture can cause the indoor climate and building structure to deteriorate.

Mould and fungi growth increases with higher humidity and they thrive in warm indoor climates where the humidity is higher than 80%, depending on the building material used.

The cleanliness of air, and consequently the healthiness of the indoor climate, depend on the growth of hazardous microbes such as mould and fungi, as well as the presence of allergens.

Mites and their droppings are considered to be a key source of house allergens. Up to 75% of a mite's body weight is water and they extract this moisture from the air. Mites therefore thrive in high humidity environments where humidity levels are around 70-80%. To keep the air healthy the WHO advises a humidity of 75% and ventilation rates of at least 50% per hour.

Low humidity also has its downside however. It increases the rate of evaporation from mucous membranes to the environment. For example, moisture in the human skin will partially evaporate, causing dry skin. The evaporation rate of tear film to the environment also increases and that can lead to irritated eyes.

The advice is, therefore, for indoor humidity to be above 35% to prevent mucous membranes from drying out.

So, for a healthy and comfortable indoor climate, it is best to have an indoor humidity of between 35 and 70%.

2. Estimating indoor humidity

A ventilation system alters the indoor climate by exchanging indoor air and moisture for outdoor air and moisture. This results in an indoor moisture load that is influenced by the outdoor climate and thus by seasonal variations.

The occupants also generate moisture. Cooking, bathing, people, plants, pets, etc. are, for example, significant sources of moisture (Figure 1).

Figure 1: moisture sources

To estimate the amount of moisture present in the home, a mathematical model has been devised to calculate all the added, removed and recovered moisture, based on hourly annual weather data from numerous major cities across Europe.

3. Model description

The model calculates the amount of moisture present in a ventilated home at every hour during the year, with latent efficiencies ranging from 0 to 100% in 1% intervals.

Latent efficiency can be explained as the amount of moisture that is transferred from one trajectory to the other. It is defined as the humidity difference between the supply outlet and inlet of the heat exchanger, divided by the humidity difference between the waste inlet and supply outlet of the heat exchanger correct by for the imbalance in mass flow.

The model assumes that the indoor temperature is kept constant at 20°C, which is standard for the Netherlands and two degrees above the advised indoor temperature by the WHO. The humidity initially has a value of 50% which is approximately the middle of the comfort range and the model starts with the first entry in the weather dataset at January first, 06.00h.

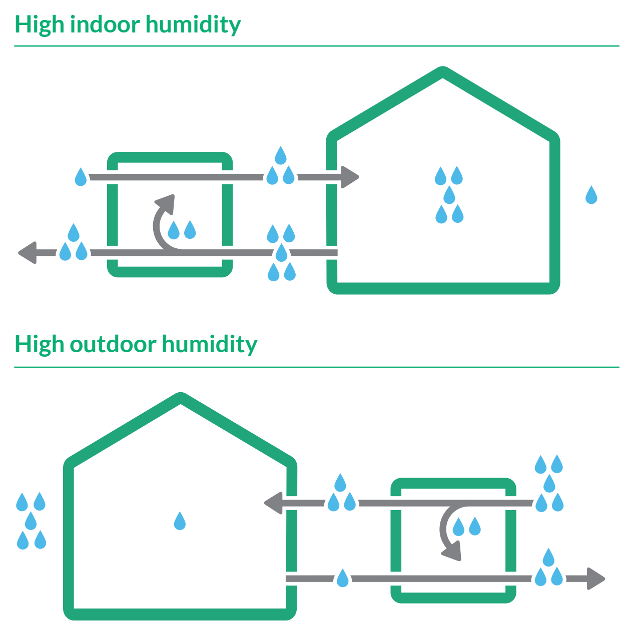


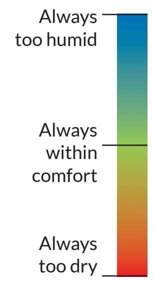
Figure 2: Moisture transport

The ventilation system replaces all indoor air every hour with fresh air which consequently also replaces the moisture. Depending on the indoor/outdoor moisture ratio, moisture will either be recovered in respect to the resident or in respect to the outside, respectively increasing or decreasing the moisture added to the home as schematically displayed in Figure 2.

Once the indoor humidity for the first hour of the year has been calculated, the result is then used for the following hour. This is repeated until the entire year has been calculated.

The model is based on multiple assumptions, such as the average number of residents and volume of owner-occupied houses in the Netherlands and the assumptions that the properties in question are perfectly insulated and have no air or thermal leaks. Some phenomena, such as the moisture buffering capacity of furniture and building materials, are not present in the model as these are all variables that may be very different for different houses and in different regions or countries.

The model is kept fairly simple so that it can be applied in multiple regions with different climates and styles of housing. This needs to be taken into consideration when reviewing the results.



4. Model results

The results from the model show the percentage that the indoor humidity is outside the comfort range of 35-70%. The humidity distribution between 'too dry-comfort-too humid' is visualised respectively by the colour gradation 'red-green-blue'.

Figure 3 depicts how different latent efficiencies influence the indoor humidity each day/month. From top to bottom the latent efficiency decreases from 100% moisture recovery to 0% moisture recovery. On the right side of the graphs, a bar depicts the annual humidity distribution.

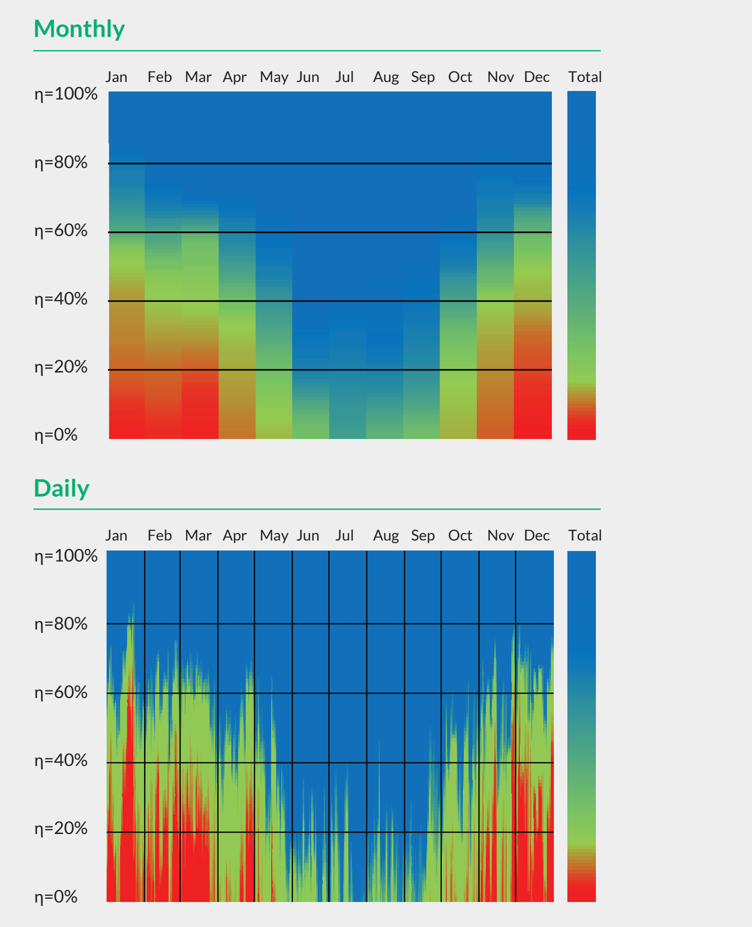


Figure 3: Indoor humidity results for Munich

From the model it seems that a latent efficiency of approximately 8% is optimal for Munich. This does not mean that 8% efficiency provides a year-round comfortable indoor climate. This is, in fact, impossible due to the seasonal variations. However, the 8% efficiency ensures that the indoor humidity is outside of the comfort range for the least amount of time during the year.

Figure 4 below depicts the humidity distribution of multiple cities, where the x-axis intersection is the optimal efficiency and negative and positive values are respectively predominantly too dry and too humid. The optimal latent efficiency appears to be 5-20% depending on the climate.

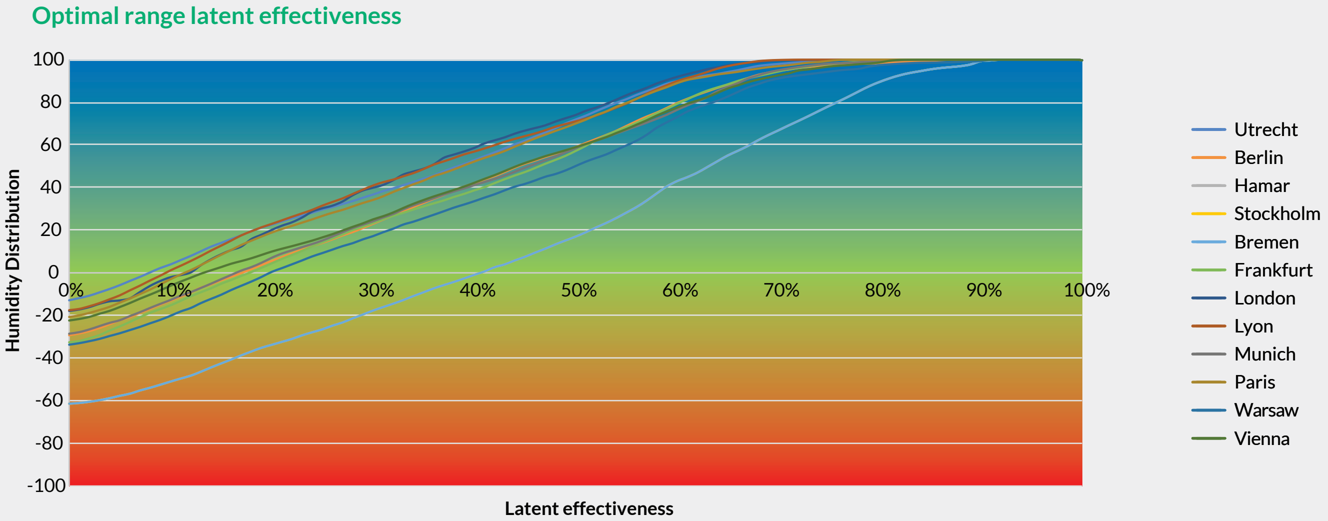


Figure 4: Optimal latent efficiency for multiple cities

5. Conclusion

Based on the results in Figure 3 and Figure 4 it can be stated that humidity recovery can be beneficial for the residence and its occupants. It is also clear that the amount of desired moisture recovery is highly dependent on the location and the local climate. Seasonal changes in weather also influence the desired recovery. Nevertheless, the high levels of moisture recovery that are customary in latent heat exchangers are mostly excessive and have the potential to harm the indoor environment of homes.

6. Literature

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