VENTILATION RATES AND INDOOR AIR HUMIDITY DEPENDING ON LOCAL CLIMATE – SIMULATIONS AND MEASUREMENTS OF 9 EUROPEAN COUNTRIES

Rainer Pfluger

University of Innsbruck, Unit Energy Efficient Buildings
Technikerstr. 13
6020 Innsbruck, Austria

ABSTRACT

Most European standards and national regulations about ventilation rates are based on indoor air quality assumptions in terms of contamination. On the other hand, indoor air humidity is important for human health as well. In case of high flow rates during the heating seasons in cold climates, the indoor air humidity tends to low values.
This presentation gives an overview of the influence of the local climate (ambient temperature and humidity) in 9 European countries at given flow rates and moisture sources. In case of low indoor air humidity, ventilation systems with humidity recovery might be an useful option. The simulations show which humidity recovery rate is necessary at which climate. Besides the simulations, real measurement data of a project in Innsbruck (Austria) are presented.

KEYWORDS
Ventilation, flow rate, indoor air humidity, climate

INTRODUCTION
The design of ventilation in climate zones which are characterized by a heating season, have to consider both, air quality as well as the humidity balance.
The ventilation flow rate should be adjusted to the moisture sources in space and occasionally reduced, especially in case of very low outside air humidity. In cold climates during heating season, the absolute external humidity is about 1 to 5 g/kg whereas the indoor absolute humidity is around 7 to 9 g/kg. Each cubic meter of air change indoor- by outdoor air takes some 2 to 8 g of water vapour out of the building. Reducing the ventilation rate and accounting for the air quality at the same time is one of the most appropriate ways of raising the indoor humidity level. If the flow rate would become to low in terms of air quality, moisture recovery helps to increase in the indoor air humidity.
Only in extreme cases humidifying action is necessary and recommended, taking into account the hygiene requirements.
This paper gives an overview of the ambient humidity and the consequences for the indoor air humidity as well as some examples of measured data.

MEASUREMENT DATA INNSBRUCK LODENAREAL (AUSTRIA)
“Measurements have been conducted since the fall of 2009 as part of the research projekt titled “Passive House residential complex in Lodenareal – indoor air quality, building services losses and household electricity consumption in Passive House rental apartments” and commissioned by the State of Tyrol and Innsbruck’s Kommunalbetriebe (Municipal Utilities Company).” [1]

Figure 1. Passive House Innsbruck Lodenareal (Austria), Monitoring in 18 dwelling units (6 dwellings in detail).

The Passive House Lodenareal (Innsbruck, Austria – see contribution of Kapferer, R. in this proceeding) consists of different apartments. In this contribution the 81 m²-type apartment is investigated. A detailed measurement evaluation was done concerning air quality and thermal comfort. In this contribution, the measurement data for CO2 and indoor air humidity is evaluated.

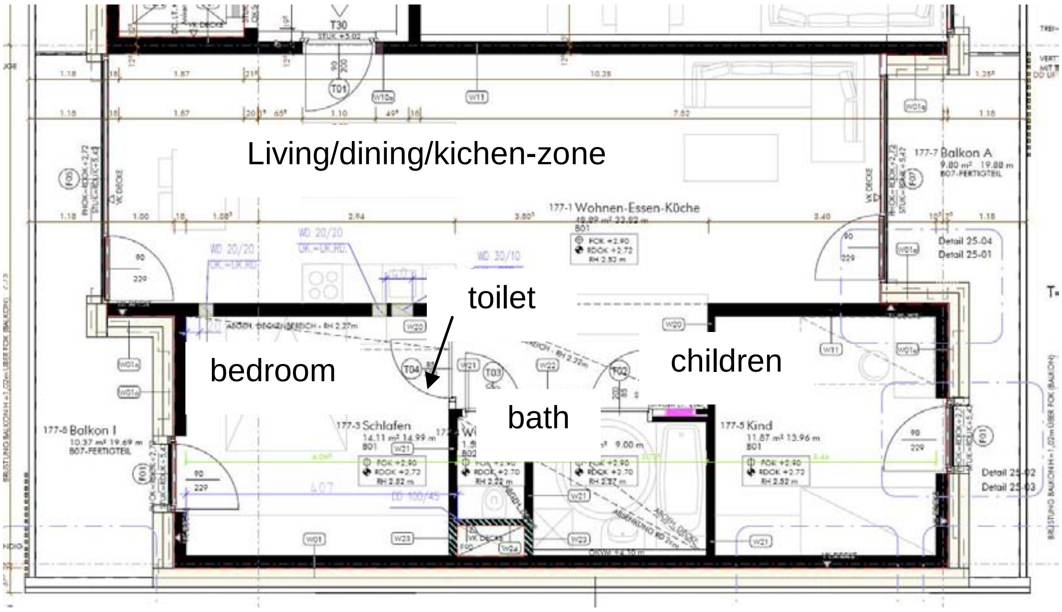

Figure 2: Floor plan of the apartment (PH Lodenareal, Innsbruck) under investigation

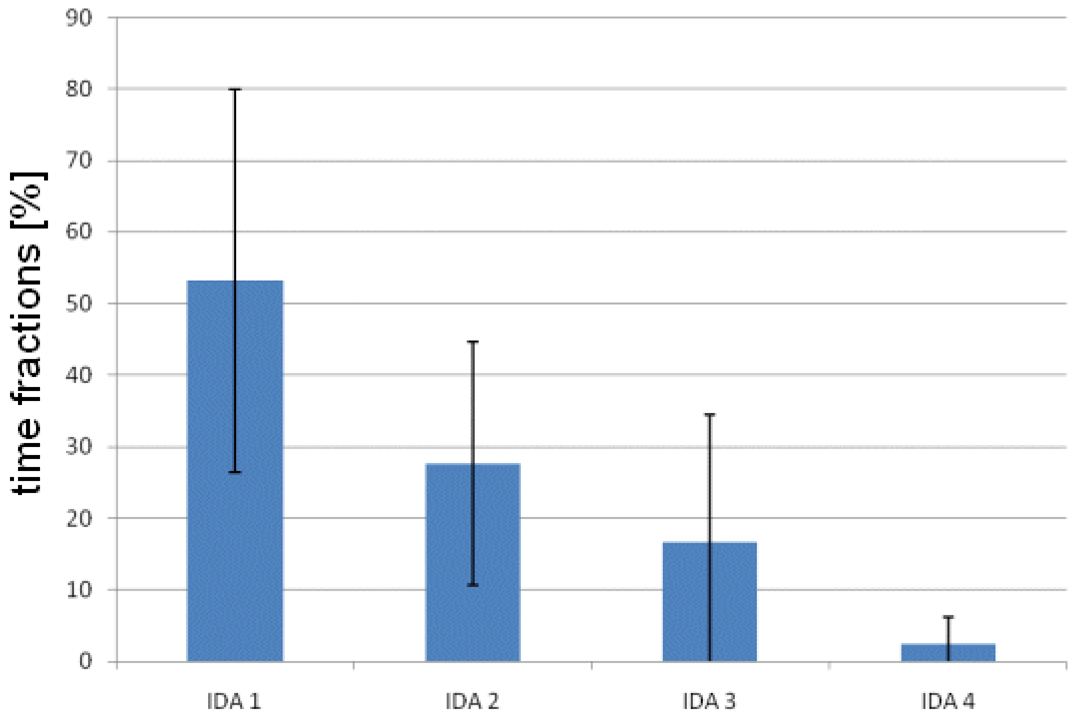

Figure 3. Measurement data of indoor air quality in living rooms of 18 dwellings (0-24 h), only Dec. 1st-Jan. 31st 2010/11

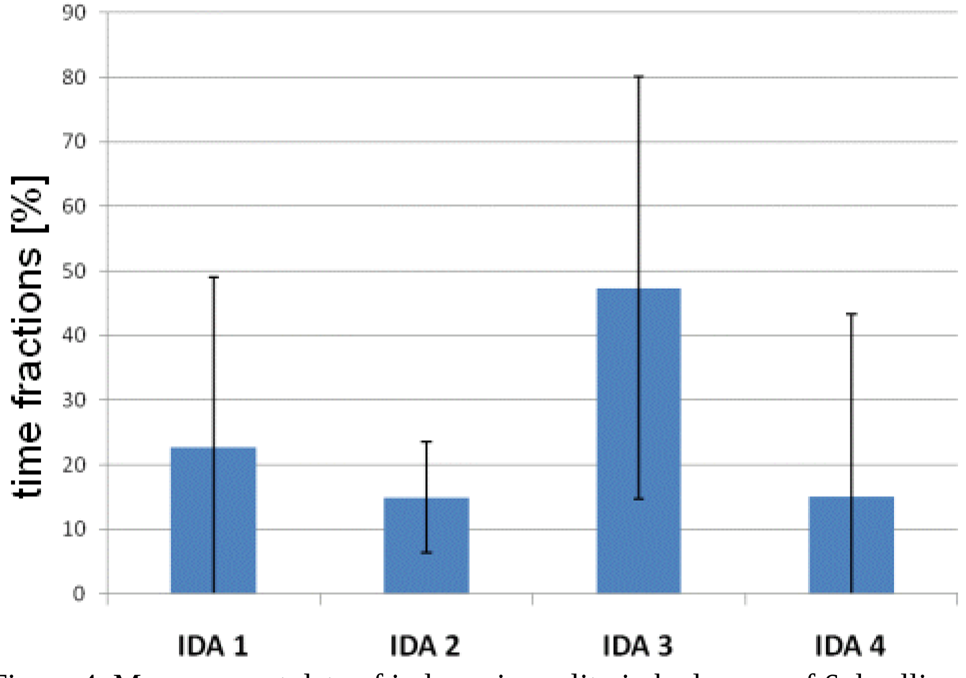

Figure 4. Measurement data of indoor air quality in bedrooms of 6 dwellings (23-7h), only Dec. 1st-Jan. 31st 2010/11

As shown in Figure 3 and Figure 4, the air quality (indicated by CO_2-concentration of the indoor air) is very good in the living rooms and rather good in the bedrooms. There is a large variation in between the individual dwellings, pointing out, that the air quality strongly depends on the number of inhabitants and their behaviour. In general, the ventilation rate of around 80 m^3/h per dwelling is low, but it shows to be adequate from air quality point of view.

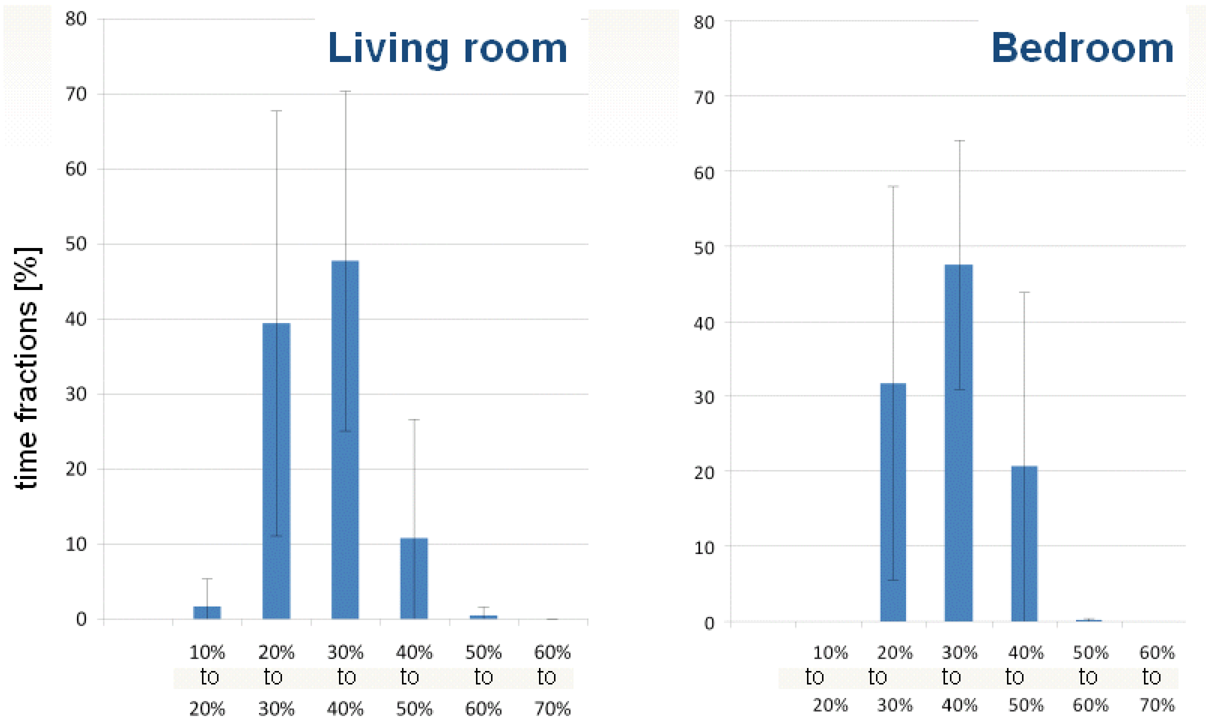

Figure 5. Measurement data of indoor relative humidity in living rooms (18 dwellings, left figure, 0-24 h) and bedrooms (6 dwellings, right figure, 23-7 h), only Dec. 1^{st}-Jan. 31^{st} 2010/11

The relative humidity measured in the living rooms and bedrooms (see Figure 5) was rather low during the core heating season. Higher flow rates without humidity recovery would not be suitable. As seen in case of the CO2-measurement data, also the humidity data show a high variation depending on the number of inhabitants and the user behaviour (humidity production and indoor air temperature). In most cases low relative humidity is also due to high indoor air temperature of around 23 °C – 24° C.

VENTILATEN FLOW RATE AND INDOOR AIR HUMIDITY BALANCE

As pointed out by the evaluation of the measurement data, there is a wide range of humidity production depending on the user behaviour.

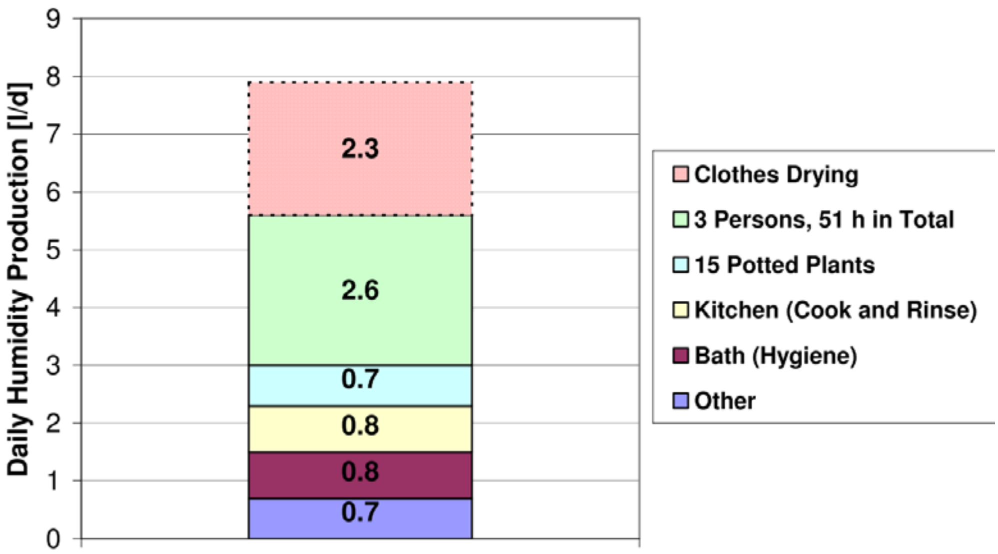

Figure 6. Daily humidity production for a family of three according to Hartmann 2001 [1]

Hartmann evaluated the daily humidity production as shown in Figure 6. Humidity is produced within the dwelling by persons, potted plants, cook and rinse, bath and others. The most important user dependant variation is the drying of clothes. According to Hartmann, this humidity production is around 2.3 l/d if the drying of clothes is done within the dwelling. For the following evaluations a mean daily humidity production of 7 l/d was used for a family of three.

As design value for the flow rate, a value of 30 m³/h per person was applied, this is found to be appropriate both in terms of air quality as well as in terms of indoor air humidity. Moreover this value is recommended in standards and guidelines.

COMPARISON OF DIFFERENT CLIMATE DATA

In order to show the climate dependancy of the indoor air humidity, some examples of ambient conditions mostly in middle and northern Europe where used. The locations of the meteostations (data from METEONORM) are illustrated in Figure 7. The absolute humidity of the ambient air not only depends on the latitude but also on the distance to the sea (e.g. the climate in Dublin and Nantes are strongly influenced by the sea whereas Kiev is a location representing continental climate).

Figure 7. Distribution of locations (hourly climate data from METEONORM), map source: google earth

In oder to illustrate the differences in absolute humidity, hourly data from Innsbruck (Austria) and Dublin (UK) are plotted versus the ambient temperature in Figure 8 and Figure 9 respectively. The red line represents the minimum value of ambient absolute humidity (2 g/kg) at which (under the given boundary conditions and assumptions, see next chapter) an indoor air humidity of at least 30 % RH can be achieved.

It can be seen, that in Dublin, there is no problem with dry air during the heating season, whereas in Innsbruck there are data points below the threshold value. This finding is in good accordance with the measurement data from Innsbruck Lodenareal presented in this paper.

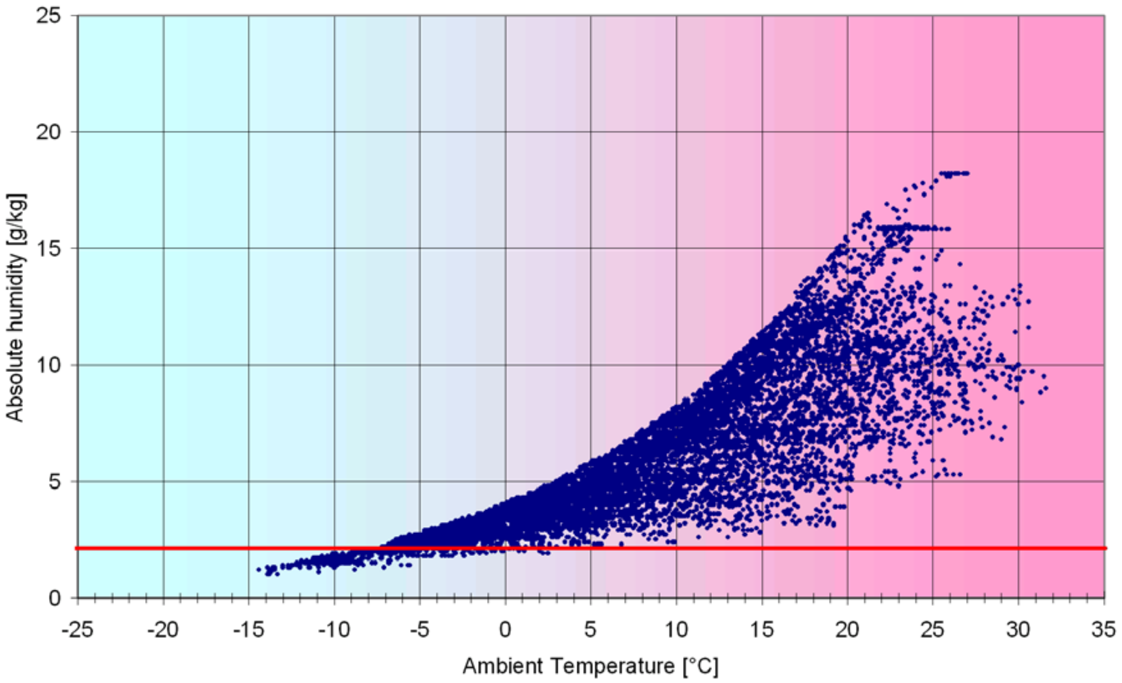

Figure 8. Hourly data of absolute humidity (METEONORM climate data Innsbruck, Austria)

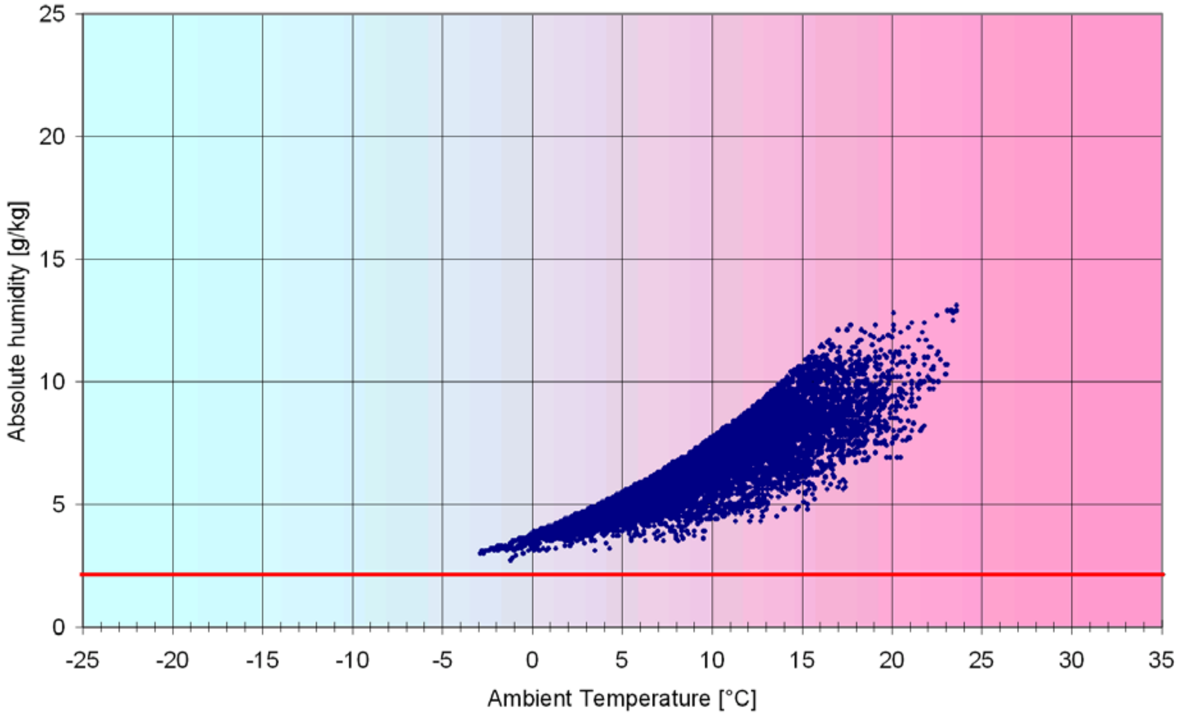

Figure 9. Hourly data of absolute humidity (METEONORM climate data Dublin, UK)

EVALUATION AND RESULTS

The climate data as described above was used as boundary condition for a simplified (without humidity buffering elements, air well mixed) humidity balace calculation for a dwelling with tree inhabitants. The assumed humidity source is 7 l of water per day, whereas the flow rate was set to a constant value of 30 m³/h per person. The relative humidity was calculated assuming an air temperature of 21 °C.

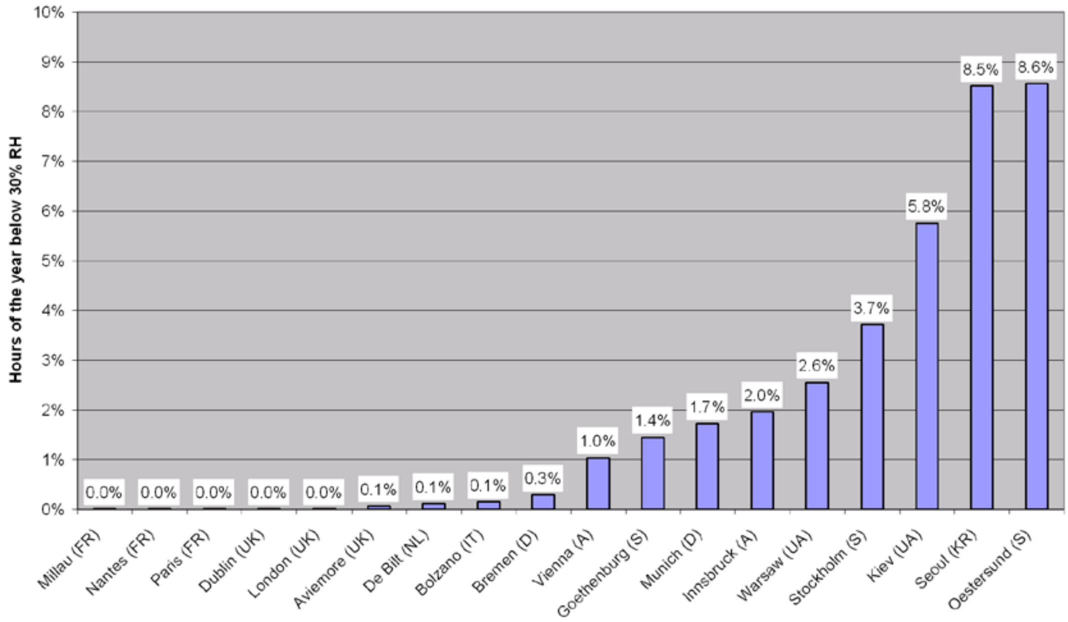

Figure 10. Hours of the year with relative indoor air humidity below 30 % (assumed ventilation rate: 30 m³/h per person)

The indoor relative humidity calculated from the humidity balance for each of the 18 climate data sets where used to evaluate the percentage of hours below 30 % RH plotted in Figure 10. In case of Milau, Nantes, Paris, Dublin, London Aviemore, De Bilt, Bolzano and Bremen, this percentage is negligible, whereas for the other locations, a certain number of hours during the heating seasons occur. For example in Stockholm the calculated result is 3.7 %, which is 324 hours (round about 2 weeks) per year with a relative humidity below 30 %.

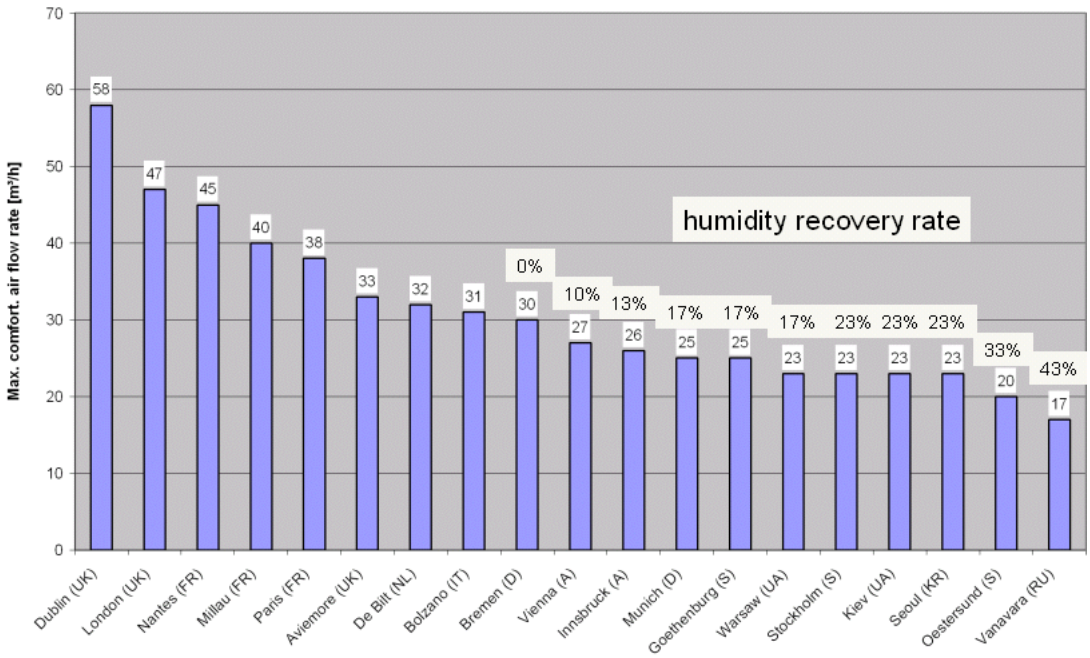

Figure 11. Maximum air flow rate per person [m³/h] with less than 1 % of the hours per year below 30 % RH and minimum necessary humidity recovery rate in case of constant flow rate of 30 m³/ per person (see labels above)

If the flow rate of 30 m³/h per person should be maintained for air quality reasons, an equivalent humidity recovery rate of 23 % would be enough to keep the percentage of hours with a relative humidity below 30 % lower than 1%.

CONCLUSION

In case of a flow rate of 25 up to 30 m³/h per person, both, indoor air quality and relative humidity is within an acceptable range for most of the European countries. In case of cold climates, humidity recovery might help to enhance the humidity level even at a constant flow rate of 30 m³/h per person. According to the simulation results, a humidity recovery rate of around 30 % is mostly sufficient to keep the indoor air humidity within the adequate range during most of the time throughout the heating season. Only in extreme cases (very low humidity sources) active humidification is necessary.

ACKNOWLEDGEMENTS

- State of Tyrol
- Innsbruck's Kommunalbetriebe (Municipal Utilities Company).
- Building owner: Neue Heimat Tirol (NHT)

REFERENCES

[1] Kapferer, R., Pfluger, R., Suschek-Berger, J. *Evaluating measurements from the Lodenareal Passive House residential complex in Innsbruck* in Feist, W. 2011.: Conference Proceedings, 15th International Passive House conference Innsbruck, 191-196

[1] Hartmann, Thomas, Ralf Gritzki, Jens Bolsius, André Kremonke, Alf Perschk, and Wolfgang Richter: *Bedarfslüftung im Wohnungsbau*. Stuttgart, Fraunhofer IRB Verlag, 2001.