EEBAK Indoor air condition study

Administration building
Länsi-Pohja healthcare district

Lapland UAS

8.3.2019

Introduction

Series of measurements were conducted in all of the project's pilot cases to verify and analyze the quality of the indoor air. The measurements were performed in similar fashion in every partaking country. The measured data included indoor temperature and relative humidity, which were monitored for four weeks total. The measurements were split in to two different periods. First two weeks in the heating season and second two weeks during the summer.

User satisfaction of the indoor air quality was analyzed by a survey conducted in a similar way in all of the pilot cases. Assumption is that the users know the characteristics of the building best since they spent the most time in the building. It is almost impossible to detect long-term variables and changes during a brief check the building.

The subject is the administration building of the Länsi-Pohja healthcare district built in 1954. The building functioned as living quarters for the doctors but in 1994, the building was converted into office spaces for the nearby hospital.

Measurements were conducted with a HDHFL-RH-measurement system, which sends data wirelessly to its base station. There were total of nine measurement points and one of them was placed outdoors.

Measurements in the administration building

The duration of all temperature and humidity measurements was at least two weeks for both heating and summer period. Measuring units were placed to the most vital and mainly used rooms in the building to analyze the conditions of the chosen spaces. In this study, there were nine measure points and the sensors were placed as shown in picture 1. Every sensor was placed on the same height and was strategically placed to avoid direct sunlight and other possible sources of error. Measurement point 7 measured the outdoor conditions. Measure points 8 and 9 also measured carbon dioxide levels in addition to temperature and relative humidity.

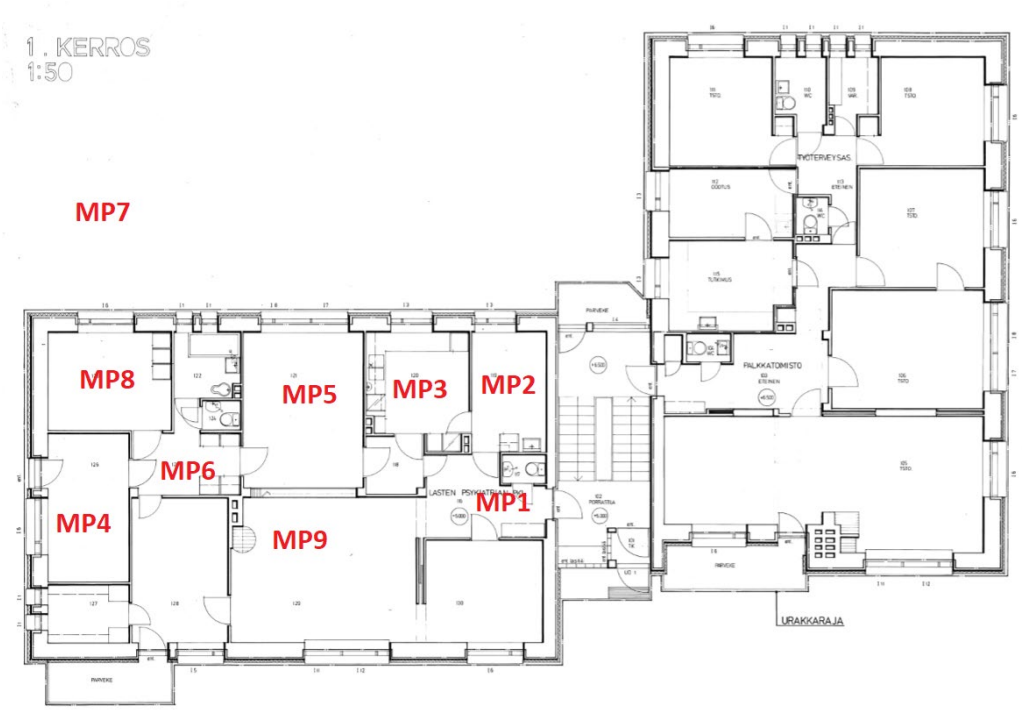

Figure 1 Measurement points in the administration building

The measurement system recorded relative humidity and temperature values and in two measurement points carbon dioxide values at hourly intervals. The measurements in the summer period were conducted during 12. –22.6.2018. The measurements in the heating period were conducted during 15.–29.1.2019. During the heating season, the sensors on the third and the seventh measure point had malfunctioned and the data from these sensors were unusable in this study.

Building information

Building type: Office building

City: Kemi

Purpose: Administration building

Construction year: 1954

Surface area: 1043 m2

Volume: 3320 m2

Heating, water and electricity:

- District heating

User surveys

In this case, user surveys were used to get a more complete picture of the indoor air condition and the user satisfaction. Even though we could measure many different parameters of the indoor air, it is important to analyze how the users experience the quality of the indoor air. Generally, the users spend the most time in the building so in theory they know the properties of the indoor air and other factors.

Unified survey was created so the results between the pilot cases could be compared. In this case, the survey needed to be translated in Finnish but short and simple questions reduced the chances of translation errors.

The extent of the questions had to do with the quality of the indoor air and the energy efficiency of the building. The users were asked to describe their satisfaction to lighting, noise, thermal comfort, moisture and the quality of the indoor air. Survey also included simple yes and no questions considering mold growth so obvious issues with the indoor air and possible health problems could be detected.

The buildings staff replied to the survey. Twenty surveys were filled and received from the staff.

Results

Heating season

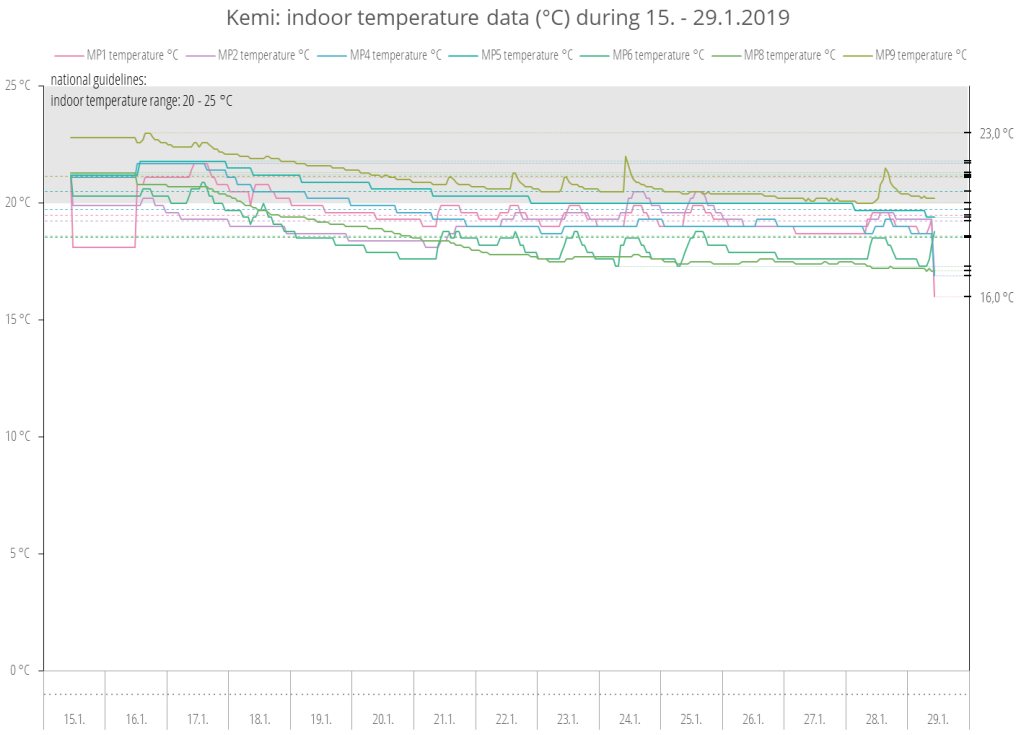

Figure 2 Temperature in the administration building during the winter period

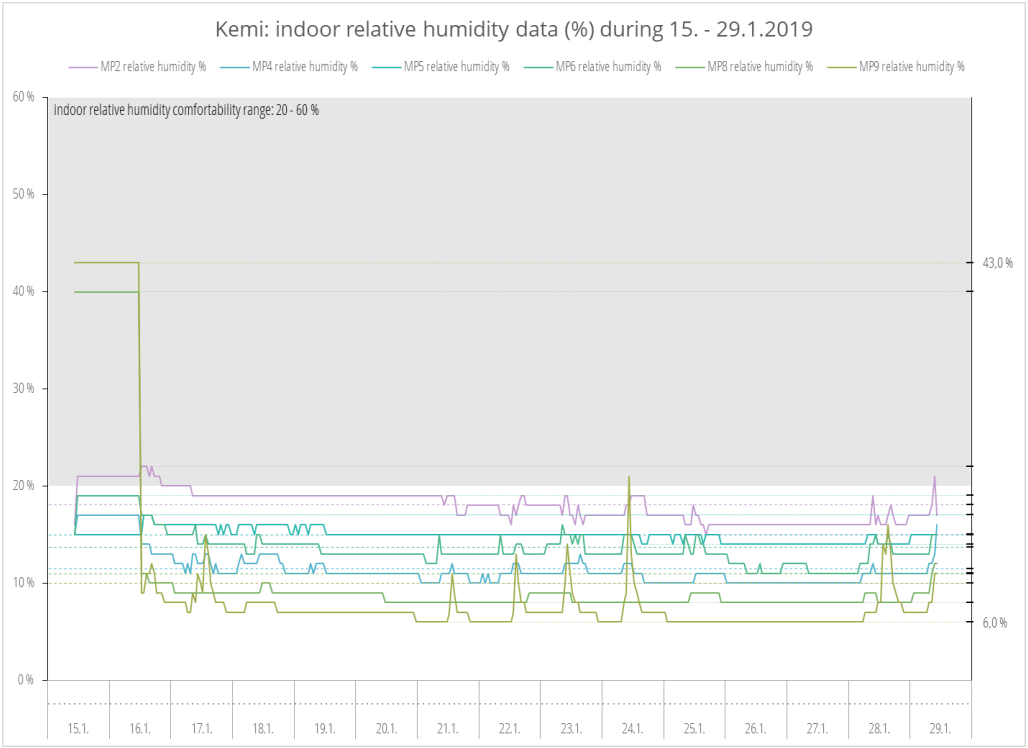

Figure 3 Relative humidity in the administration building during the winter period

Measurement point 1

The average temperature of the indoor air in the room was 19.5 °C during the measurement period. The temperature of the room varied between 19–21 °C for the most part of the measurement period. The lowest measured temperature in the room was 18.1 °C and the highest 21.7 °C. The temperature lowered below the national guideline of 20 °C by few degrees during the period.

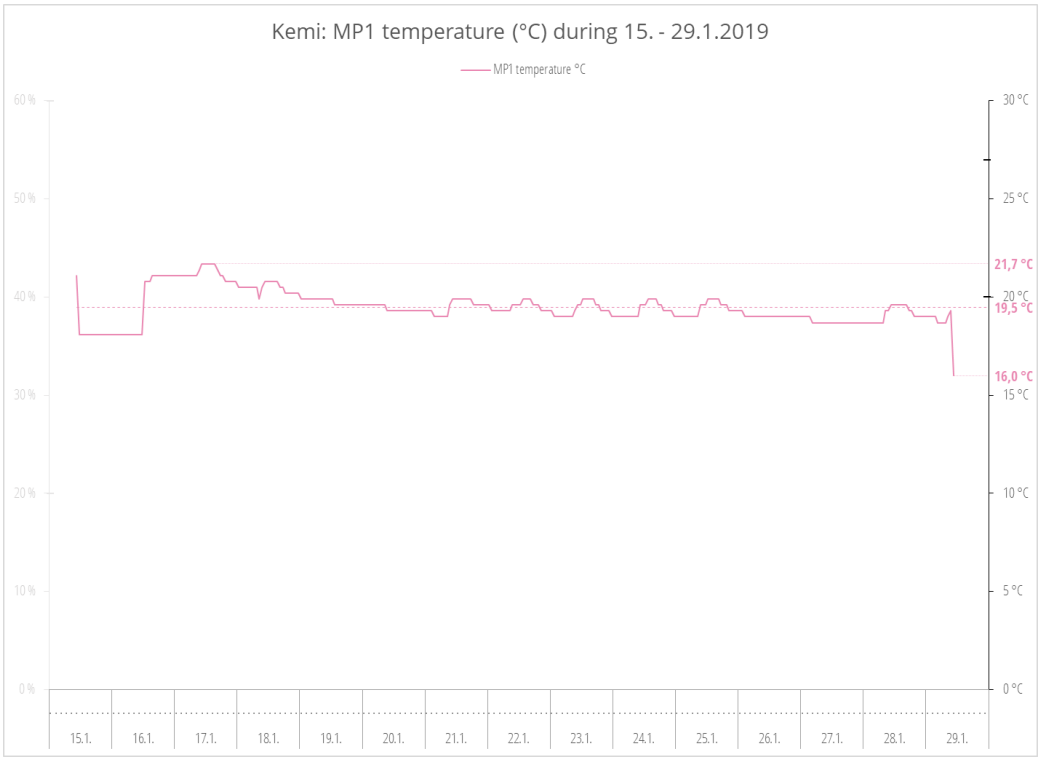

Figure 4 Temperature in the measurement point 1 during the measurement period

Measurement point 2

The average temperature of the indoor air in the room was 19.2 °C during the measurement period. The temperature of the room varied between 19–21 °C for the most part of the measurement period. The lowest measured temperature in the room was 18.1 °C and the highest 21.1 °C. The temperature lowered below the national guideline of 20 °C by few degrees during the period.

The average of the relative humidity in the room was 18 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 22 % and lowest was 15 %.

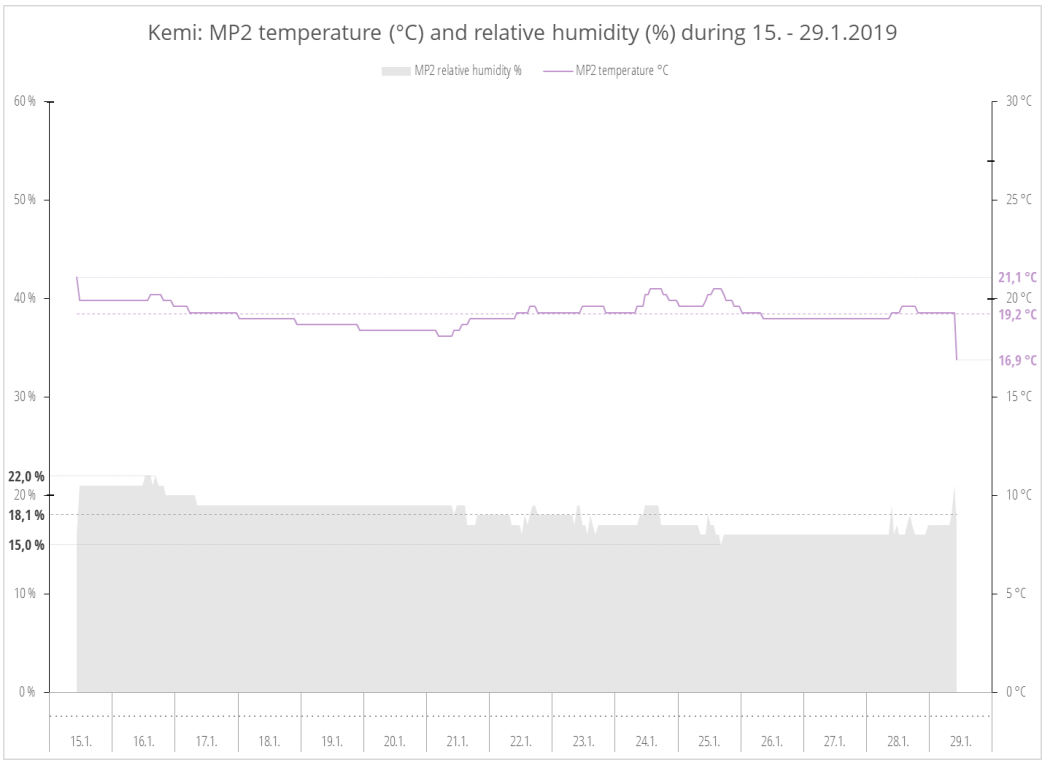

Figure 5 Temperature and relative humidity in the measurement point 2 during the measurement period

Measurement point 4

During the measurement period, the average temperature of the indoor air in the room was 19.7 °C. The temperature of the room varied between 19–21 °C for the most part of the measurement period. The lowest measured temperature in the room was 18.7 °C and the highest 21.7 °C. The temperature lowered below the national guideline of 20 °C by few degrees during the period.

The average of the relative humidity in the room was 11.5 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 17 % and lowest was 10 %.

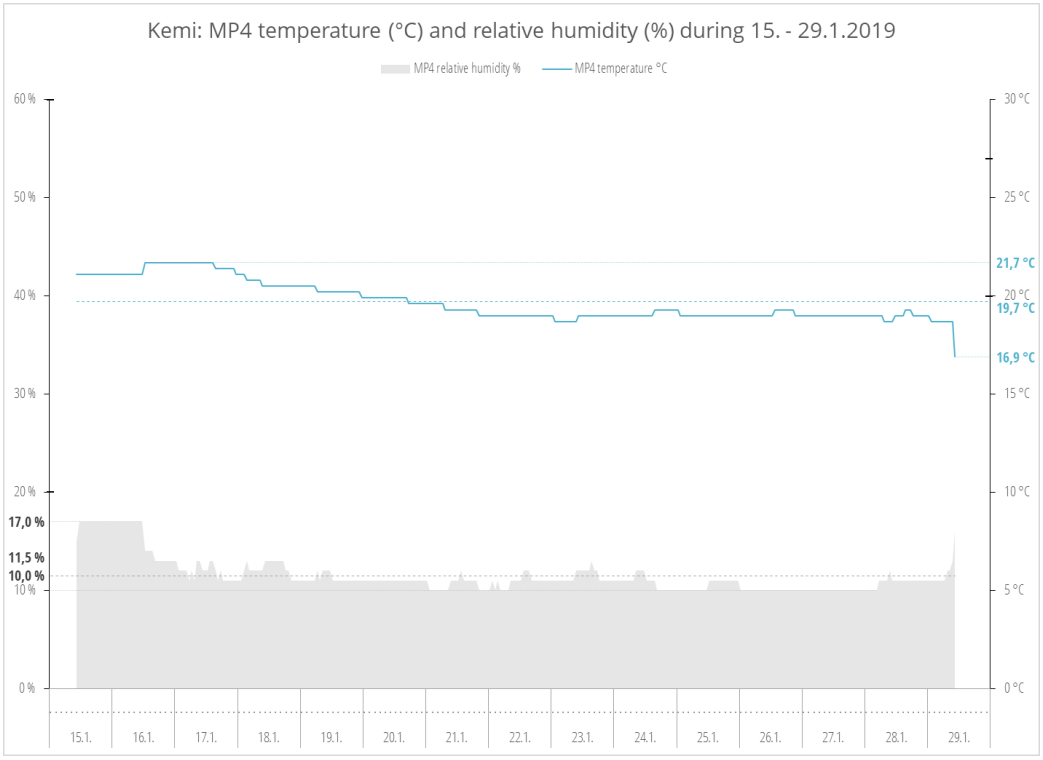

Figure 6 Temperature and relative humidity in the measurement point 4 during the measurement period

Measurement point 5

The average temperature of the indoor air in the room was 20.5 °C during the measurement period. The temperature of the room varied between 19–21 °C for the most part of the measurement period. The lowest measured temperature in the room was 19.4 °C and the highest 21.8 °C. The temperature lowered below the national guideline of 20 °C by less than a degree during the period.

The average of the relative humidity in the room was 15 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 17 % and lowest was 14 %.

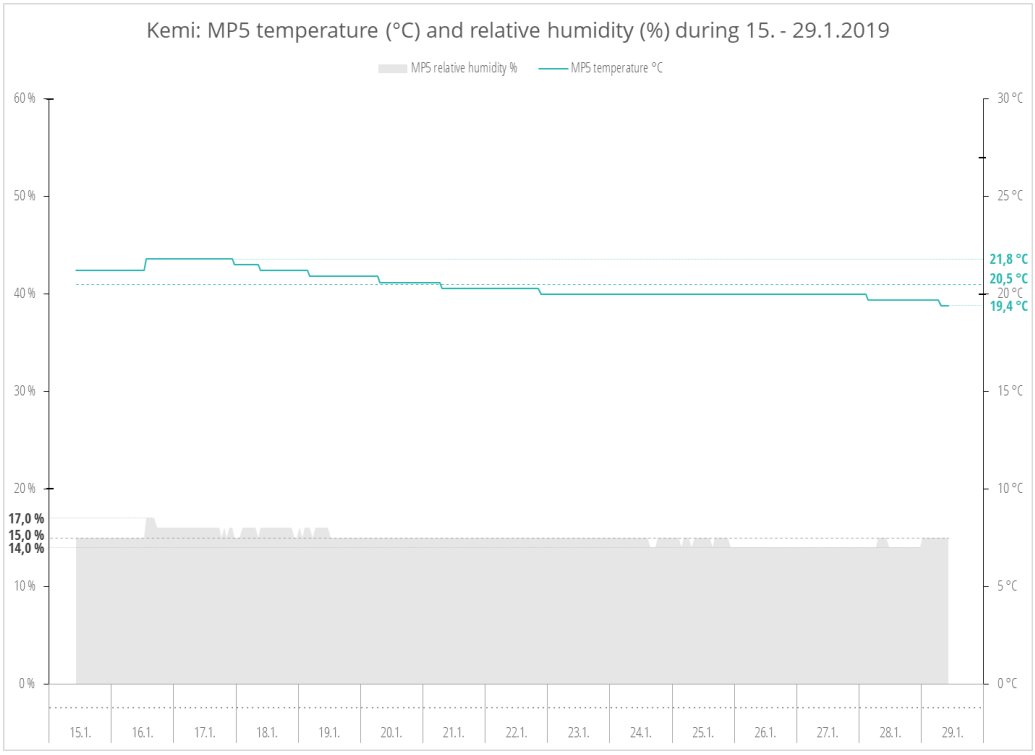

Figure 7 Temperature and relative humidity in the measurement point 5 during the measurement period

Measurement point 6

During the measurement period, the average temperature of the indoor air in the room was 18.5 °C. The temperature of the room varied between 18–20 °C for the most part of the measurement period. The lowest measured temperature in the room was 17.3 °C and the highest 21.2 °C. The temperature lowered below the national guideline of 20 °C by few degrees during the period.

The average of the relative humidity in the room was 13.7 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 19 % and lowest was 11 %.

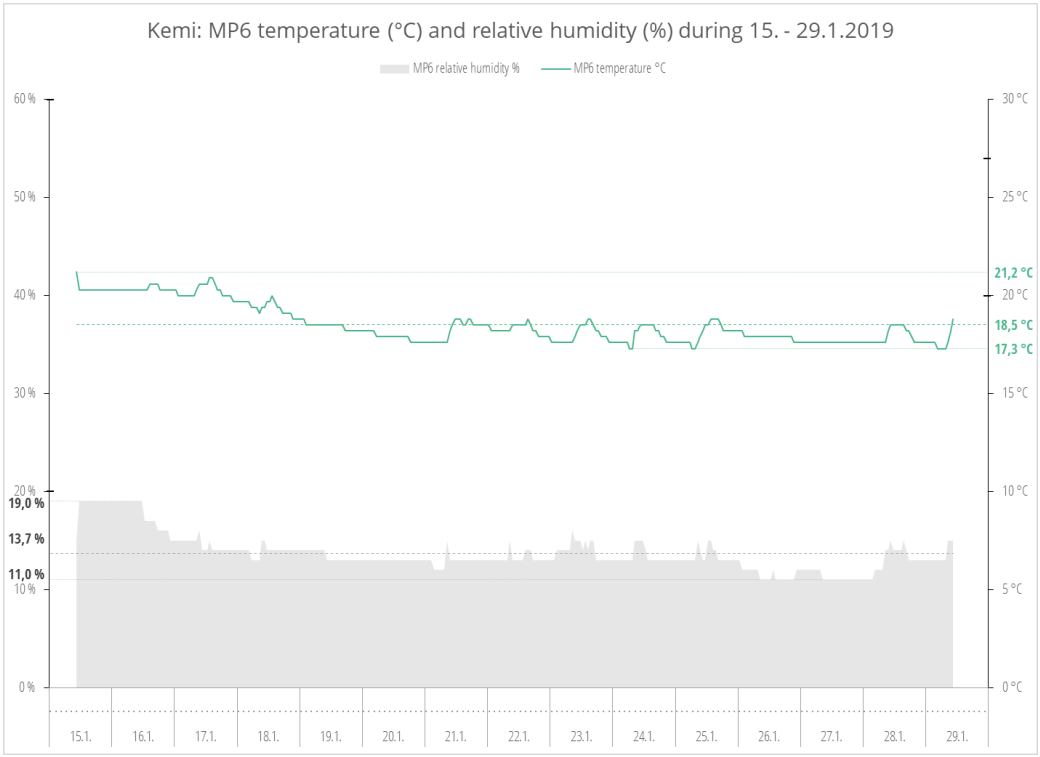

Figure 8 Temperature and relative humidity in the measurement point 6 during the measurement period

Measurement point 8

The average temperature of the indoor air in the room was 18.6 °C during the measurement period. The temperature of the room varied between 20–21 °C for the first part of the measurement period. For the rest of the period the temperature lowered from 20 °C to nearly 17 °C. The lowest measured temperature in the room was 17.1 °C and the highest 21.3 °C.

The average of the relative humidity in the room was 11 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 40 % and lowest was 8 %.

In this room, carbon dioxide was also measured. The results varied between 430 ppm and 570 ppm. The average value of carbon dioxide in the room was 448 ppm.

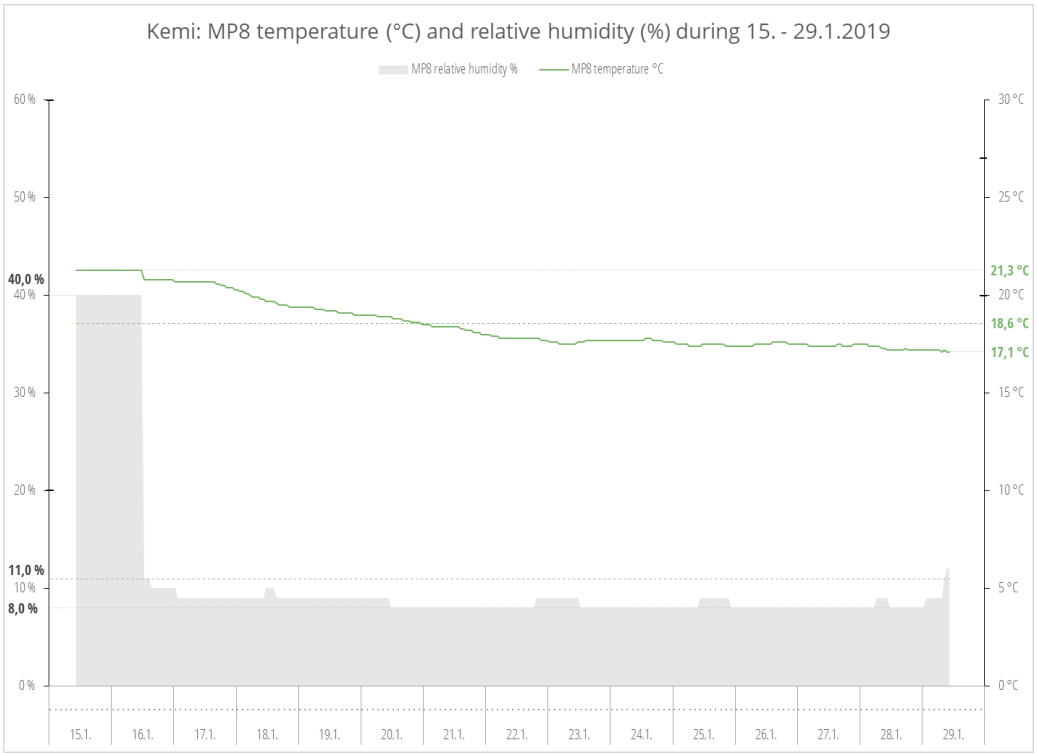

Figure 9 Temperature and relative humidity in the measurement point 8 during the measurement period

Measurement point 9

The average temperature of the indoor air in the room was 21.1 °C during the measurement period. The temperature of the room varied between 20–23 °C during the measurement period. The lowest measured temperature in the room was 20 °C and the highest 23 °C. The temperature stayed over the national guideline of 20 °C for the whole period.

The average of the relative humidity in the room was 10 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 43 % and lowest was 6 %.

In this room, carbon dioxide was also measured. The results varied between 420 ppm and 2000 ppm. The average value of carbon dioxide in the room was 516 ppm.

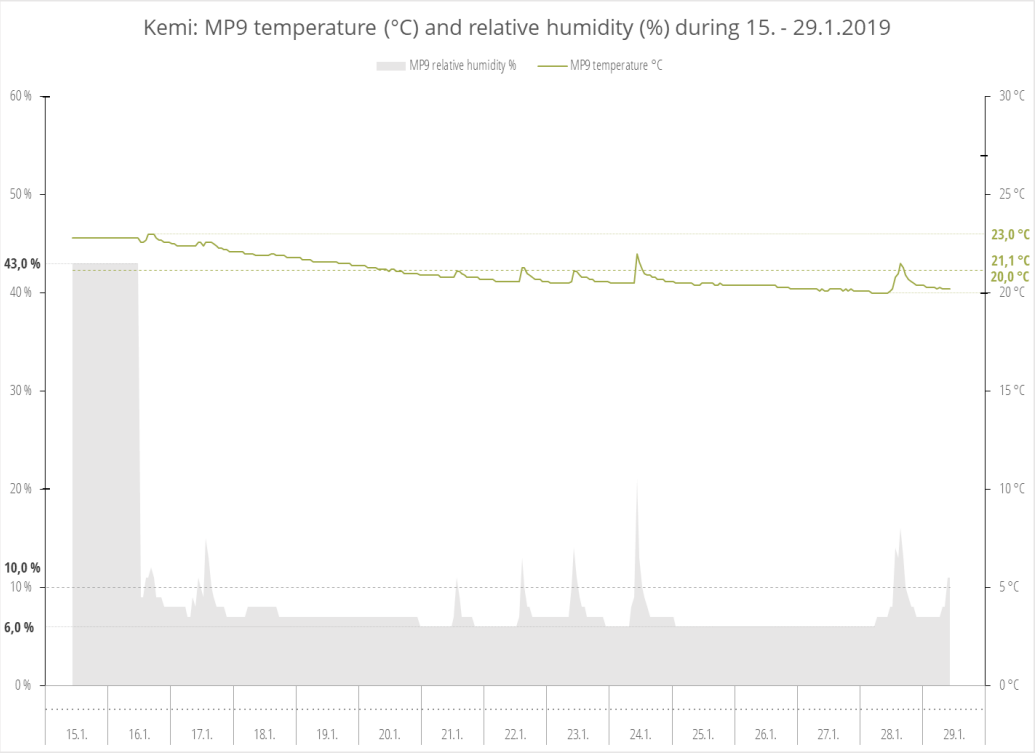

Figure 10 Temperature and relative humidity in the measurement point 9 during the measurement period

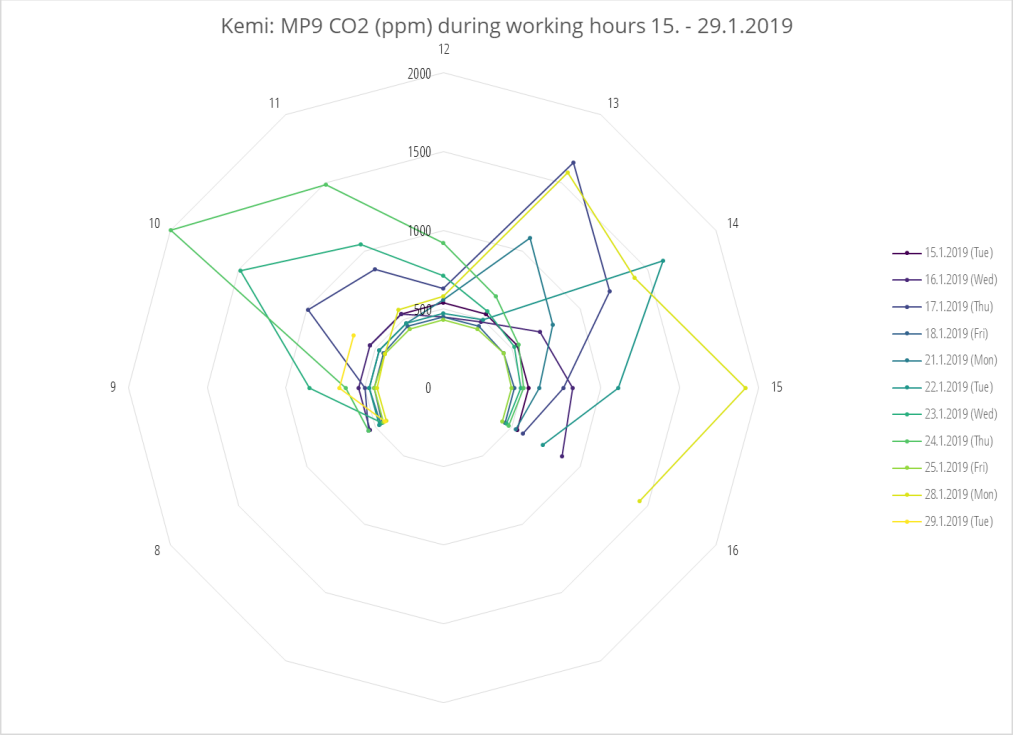

Figure 11 Carbon dioxide levels at the measurement point 9 during the measurement period

In the measurement point nine, which is the conference room, carbon dioxide levels were observed. In the conference room high levels of carbon dioxide was detected during use and after. Regardless of the high amount of outlet vents, the air conditioning in the room is not enough. The highest carbon dioxide levels of 2000 ppm exceeds the standards set by the ministry of environment. According to the standards, the indoor air should not exceed 800 ppm over the carbon dioxide levels of the outdoor air.

Weather data during the heating period

The average outside temperature was -21.2 °C. The outside temperature varied between -9.3 °C and -31.4 °C. During the measurement period, there was a frost period but the weather was typical considering the Finnish climate.

The relative humidity varied between 87 % and 71 &, the average being 79.4 %. High relative humidity is typical during winter.

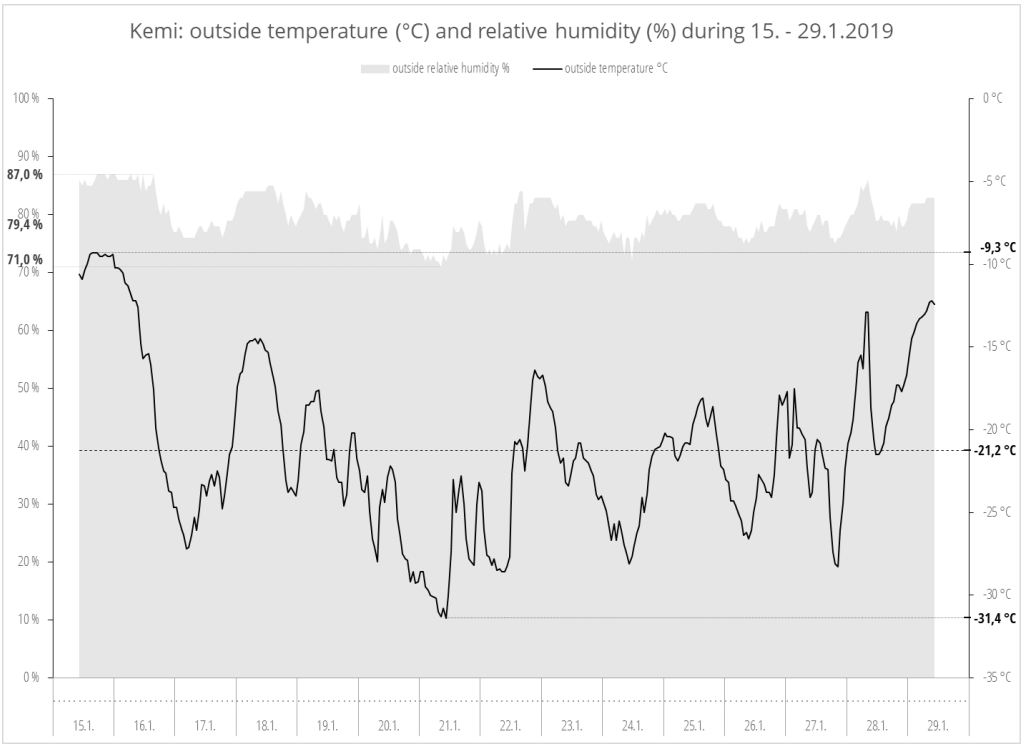

Figure 12 Outdoor temperature and relative humidity during the measurement period

Summer season

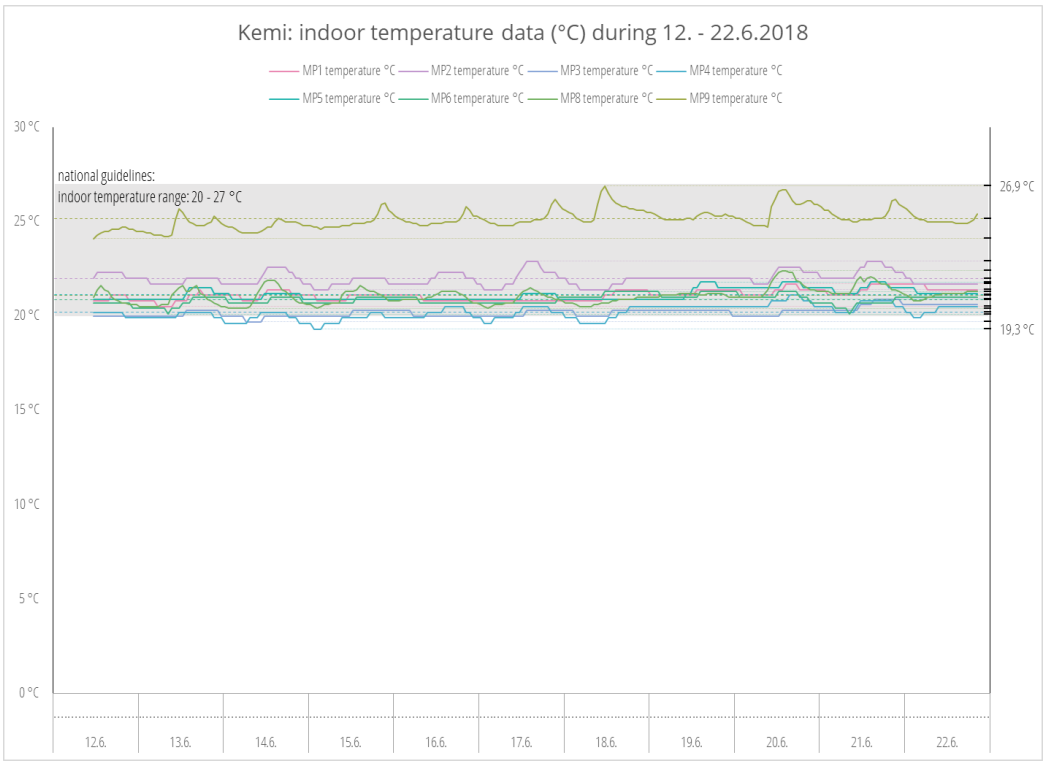

Figure 13 Temperature in the administration building during the summer period

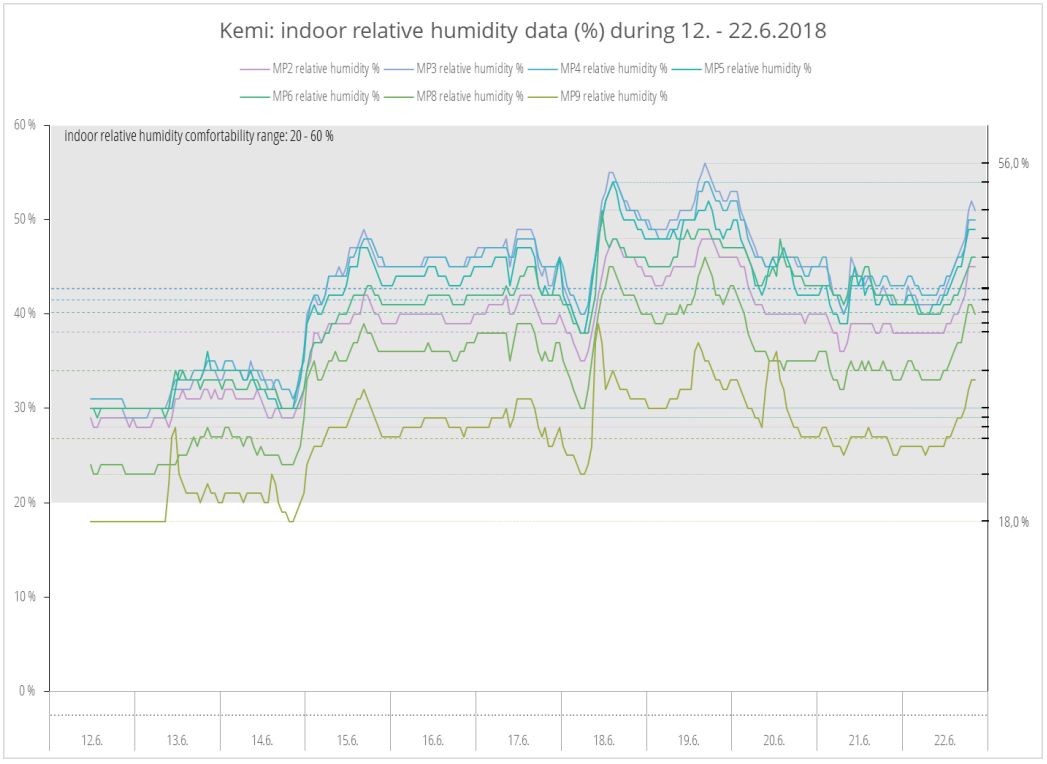

Figure 14 Relative humidity in the administration building during the summer period

Measurement point 1

The average temperature of the indoor air in the room was 21.1 °C during the measurement period. The temperature of the room varied between 20–22 °C during the measurement period. The lowest measured temperature in the room was 20.5 °C and the highest 21.7 °C. The temperature stayed over the national guideline of 20 °C and did not go over too much.

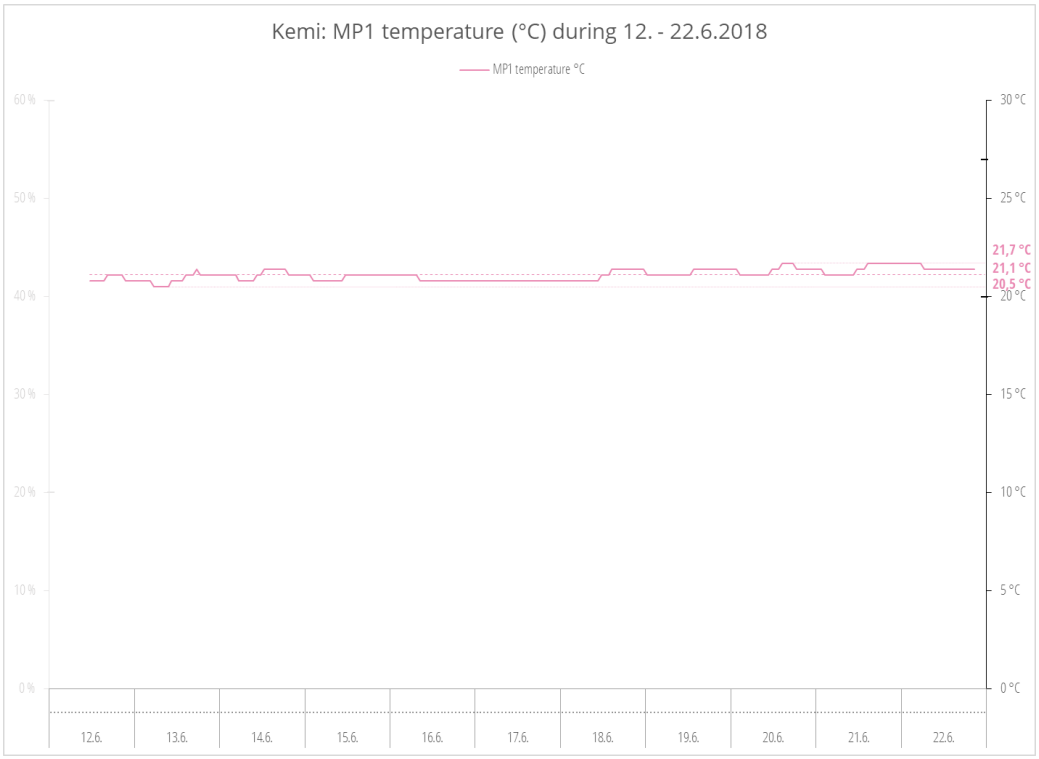

Figure 15 Temperature in the measurement point 1 during the measurement period

Measurement point 2

The average temperature of the indoor air in the room was 22 °C during the measurement period. The temperature of the room varied between 21–23 °C during the measurement period. The lowest measured temperature in the room was 21.4 °C and the highest 22.9 °C. The temperature stayed over the national guideline of 20 °C and did not go over too much.

The average of the relative humidity in the room was 38 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 48 % and lowest was 28 %.

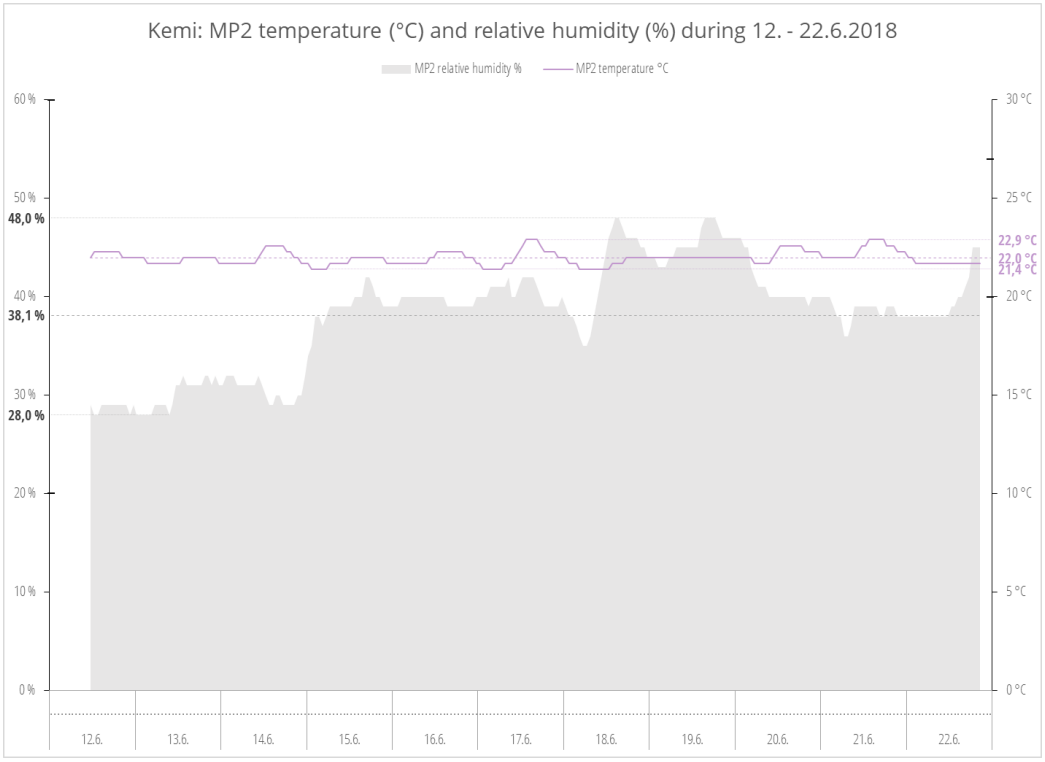

Figure 16 Temperature and relative humidity in the measurement point 2 during the measurement period

Measurement point 3

The average temperature of the indoor air in the room was 20.2 °C during the measurement period. The temperature of the room varied between 20–21 °C during the measurement period. The lowest measured temperature in the room was 19.7 °C and the highest 20.9 °C. The temperature stayed near the national guideline of 20 °C.

The average of the relative humidity in the room was 42.7 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 56 % and lowest was 29 %.

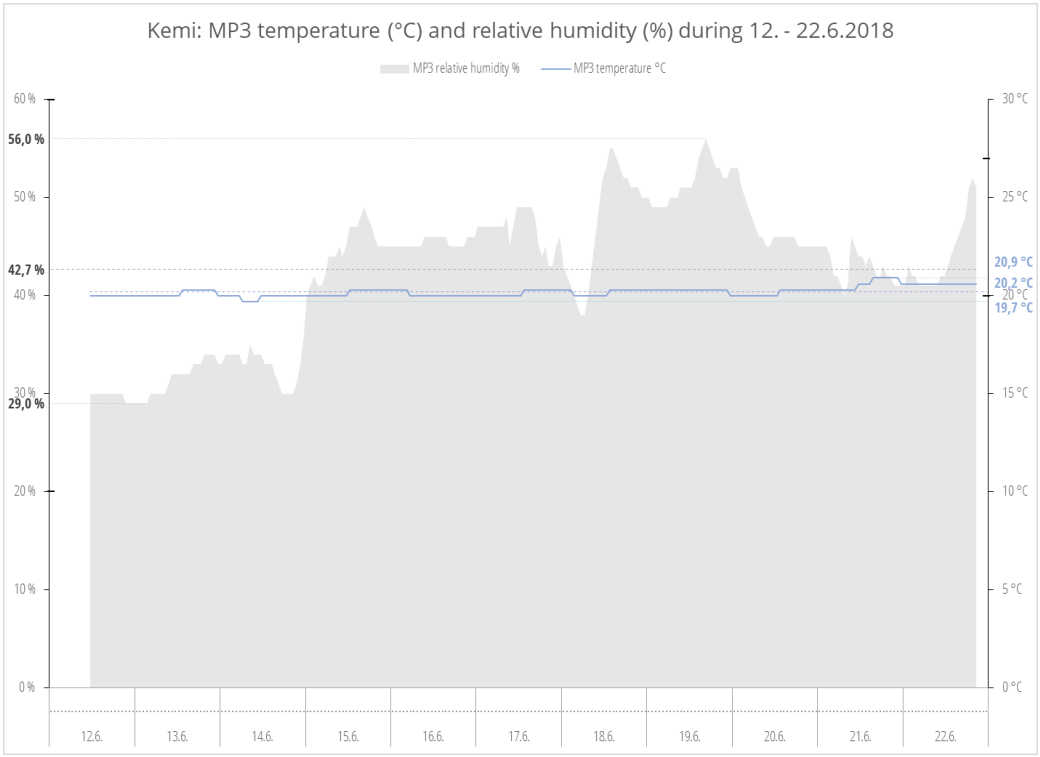

Figure 17 Temperature and relative humidity in the measurement point 3 during the measurement period

Measurement point 4

During the measurement period, the average temperature of the indoor air in the room was 20.2 °C. The temperature of the room varied between 19–21 °C. The lowest measured temperature in the room was 19.3 °C and the highest 21.1 °C. The temperature stayed near the national guideline of 20 °C.

The average of the relative humidity in the room was 42.8 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 54 % and lowest was 30 %.

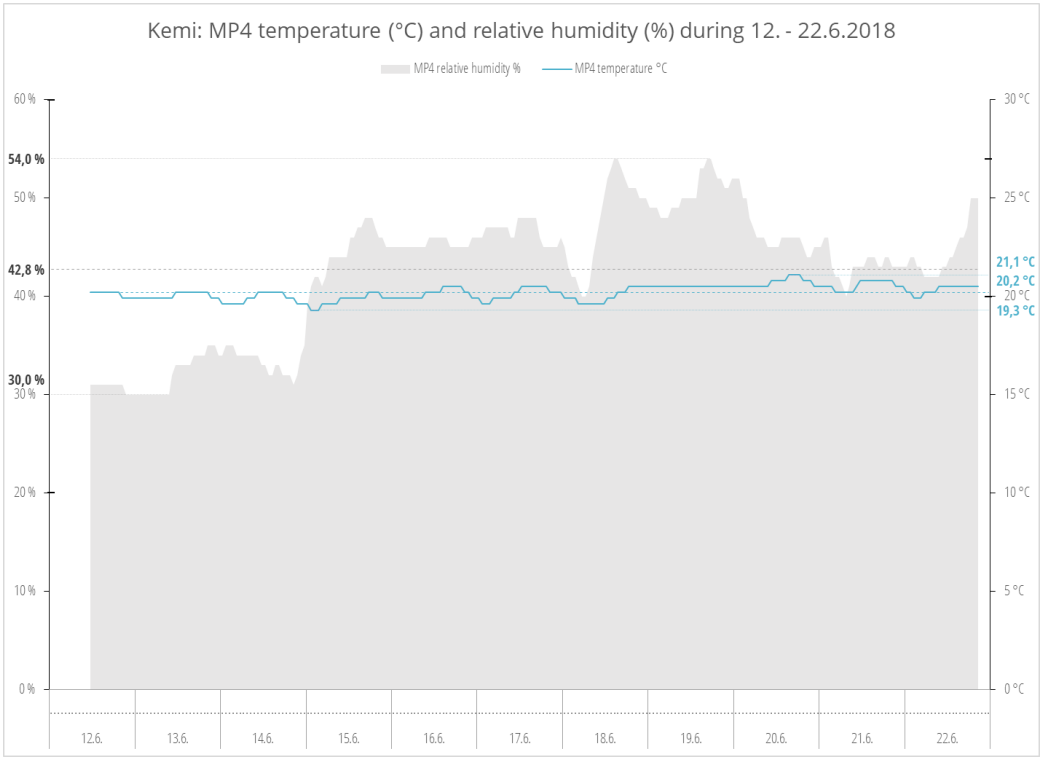

Figure 18 Temperature and relative humidity in the measurement point 4 during the measurement period

Measurement point 5

The average temperature of the indoor air in the room was 21.1 °C during the measurement period. The temperature of the room varied between 21–22 °C. The lowest measured temperature in the room was 20.9 °C and the highest 21.8 °C. The temperature stayed over the national guideline of 20 °C and did not go over too much.

The average of the relative humidity in the room was 41.5 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 54 % and lowest was 30 %.

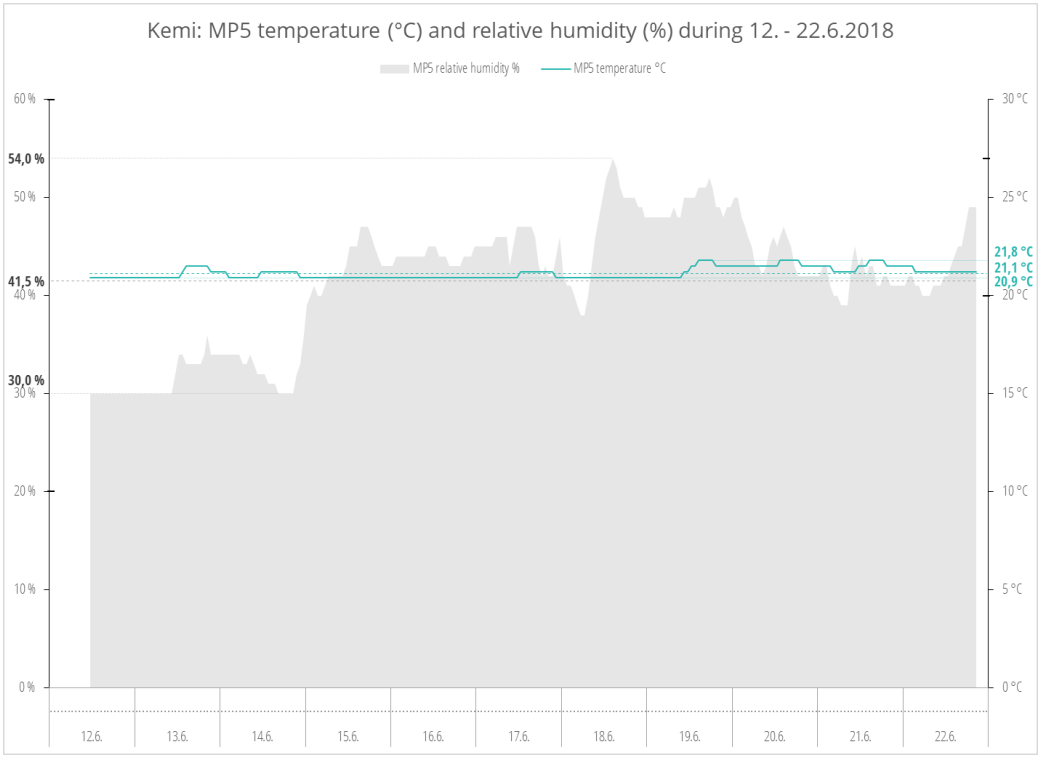

Figure 19 Temperature and relative humidity in the measurement point 5 during the measurement period

Measurement point 6

During the measurement period, the average temperature of the indoor air in the room was 20.9 °C. The temperature of the room varied between 20–21 °C. The lowest measured temperature in the room was 20.1 °C and the highest 21.3 °C. The temperature stayed over the national guideline of 20 °C and did not go over too much.

The average of the relative humidity in the room was 40.2 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 51 % and lowest was 29 %.

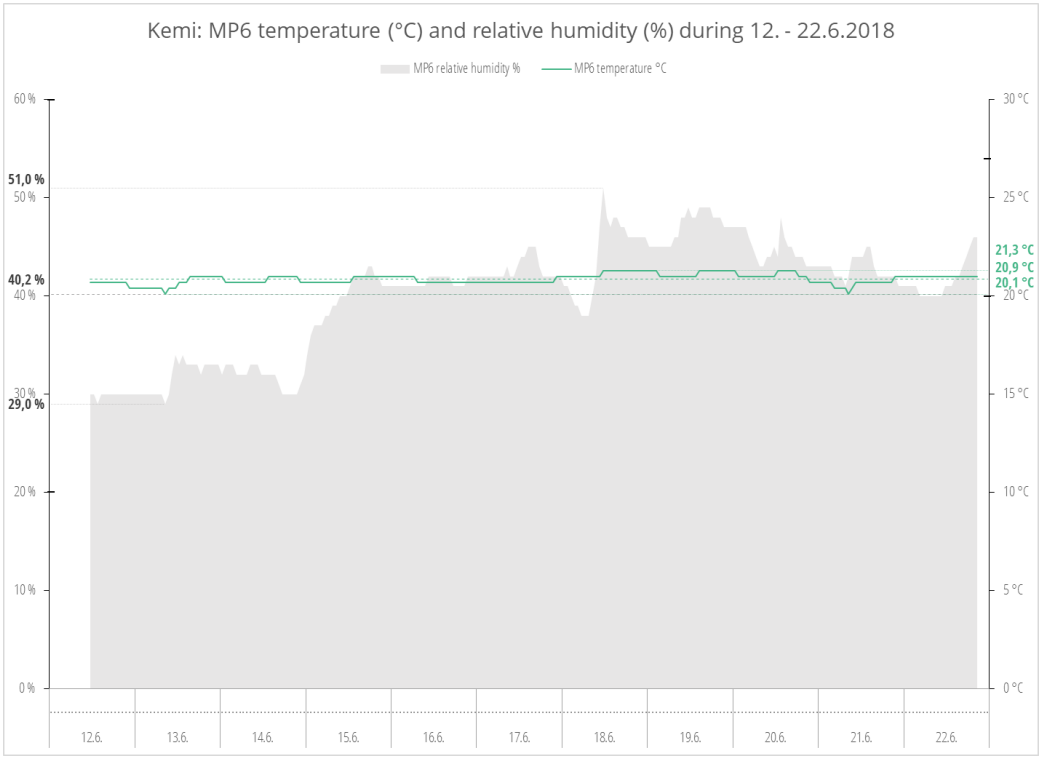

Figure 20 Temperature and relative humidity in the measurement point 6 during the measurement period

Measurement point 7

Measurement point 7 measured the relative humidity and temperature outside the administration building. The average of the relative humidity was 68.4 % and the average temperature was 14 °C. The highest relative humidity value was 98 % and thje lowest 26 %. The highest temperature value was 30.3 °C and lowest 5.7 °C. During the summer period all typical forms of Finnish weather happened which is shown by the diversity of the results.

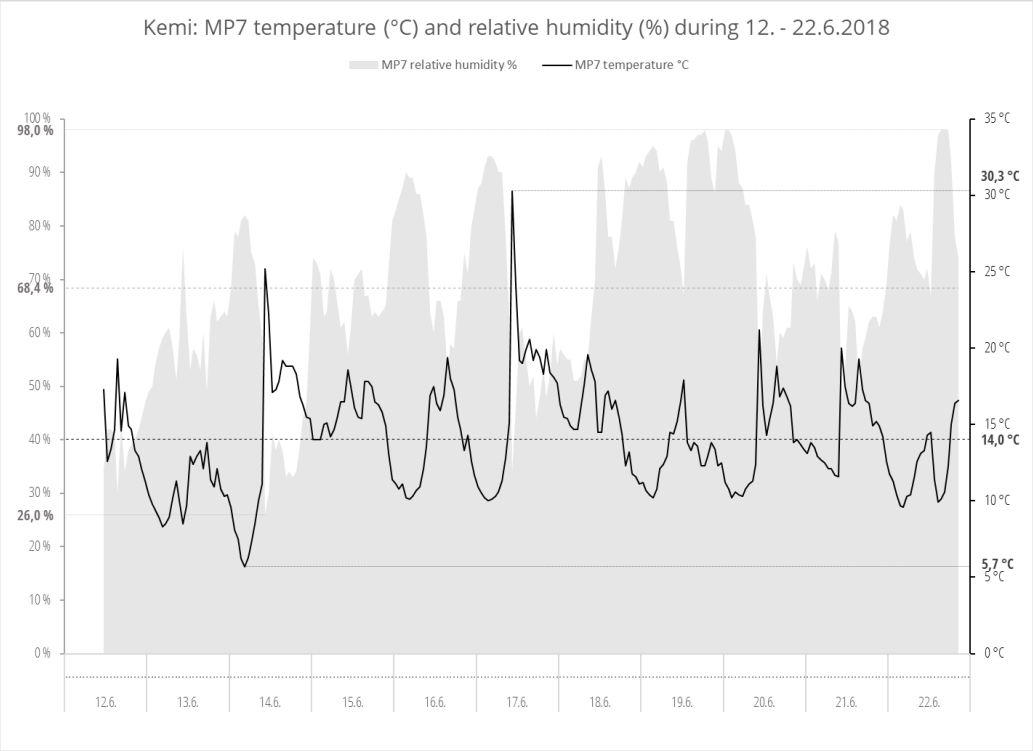

Figure 21 Temperature and relative humidity in the measurement point 7 during the measurement period

Measurement point 8

The average temperature of the indoor air in the room was 21.1°C during the measurement period. The temperature of the room varied between 20–22 °C during the period. The lowest measured temperature in the room was 20.4 °C and the highest 22.4 °C. The temperature stayed over the national guideline of 20 °C and did not go over too much.

The average of the relative humidity in the room was 34 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 46 % and lowest was 23 %.

In this room, carbon dioxide was also measured. The results varied between 410 ppm and 660 ppm. The average value of carbon dioxide in the room was 457 ppm.

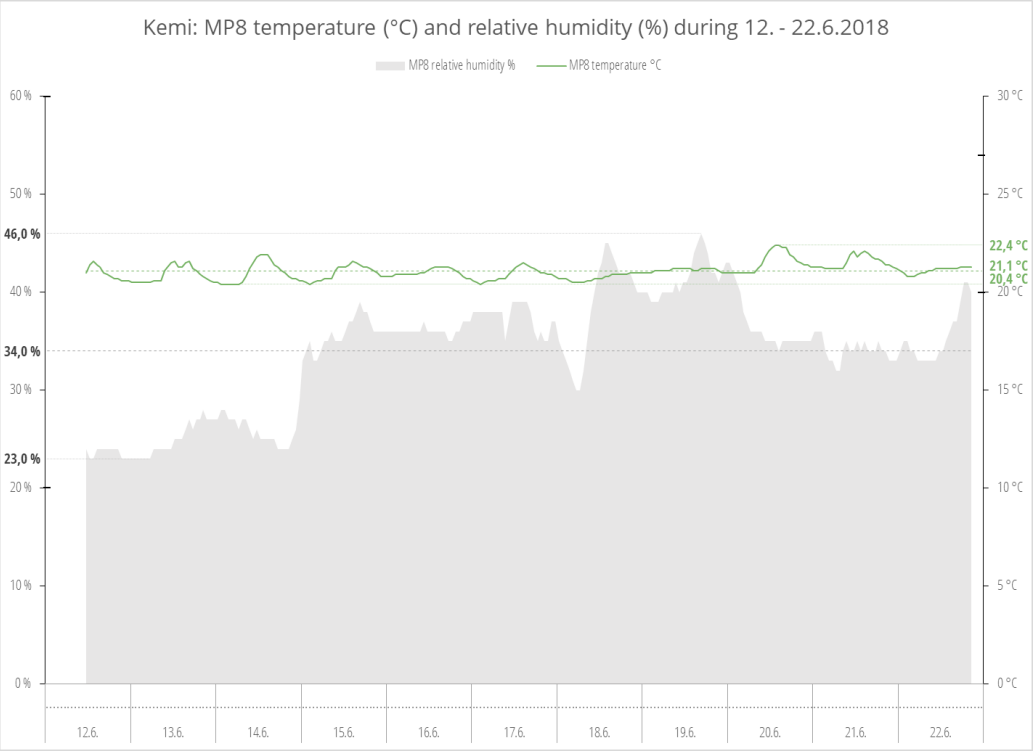

Figure 22 Temperature and relative humidity in the measurement point 8 during the measurement period

Measurement point 9

The average temperature of the indoor air in the room was 25.1 °C during the measurement period. The temperature of the room varied between 24–27 °C during the measurement period. The lowest measured temperature in the room was 24.1 °C and the highest 26.9 °C. The temperature stayed over the national guideline of 20 °C for the whole period and did not go over too much.

The average of the relative humidity in the room was 27 %. Relative humidity did not reach alarming numbers from structural point of view. The highest measured value was 39 % and lowest was 18 %.

In this room, carbon dioxide was also measured. The results varied between 420 ppm and 2000 ppm. The average value of carbon dioxide in the room was 514 ppm.

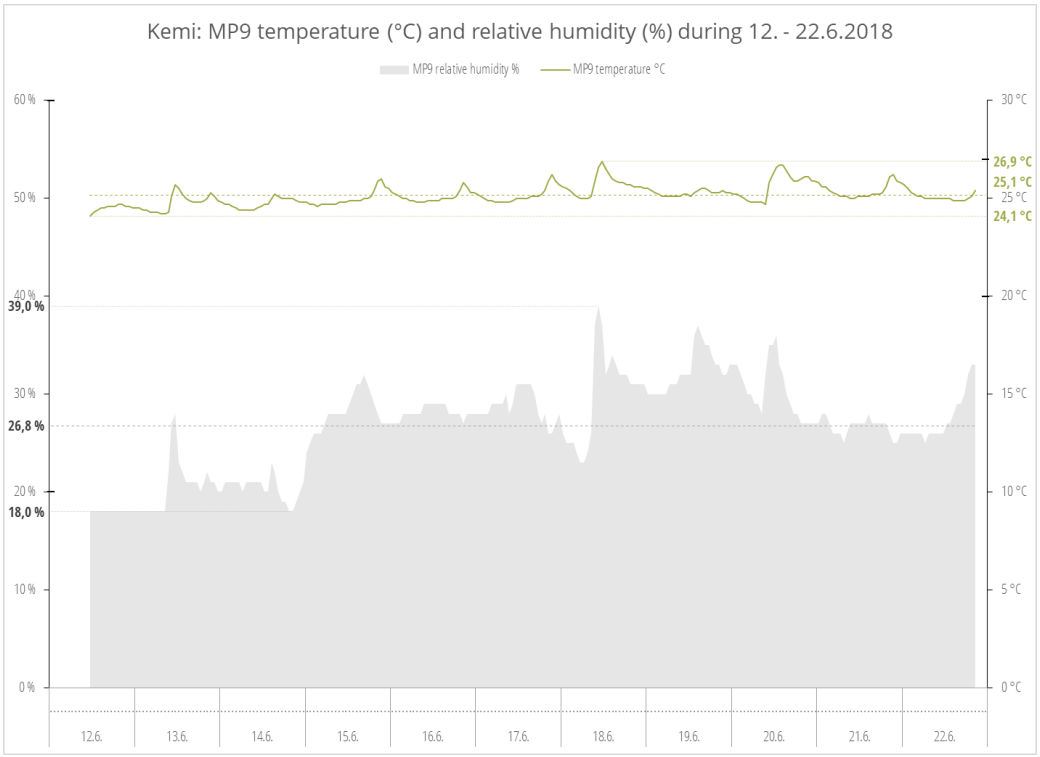

Figure 23 Temperature and relative humidity in the measurement point 9 during the measurement period

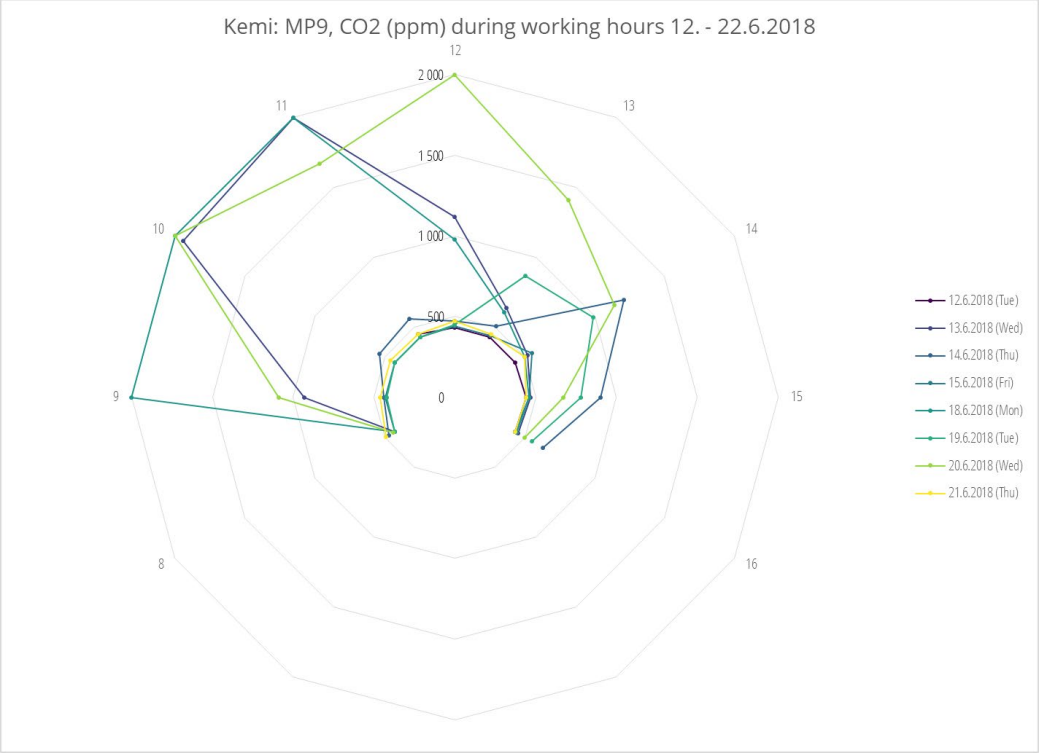

Figure 24 Carbon dioxide levels at the measurement point 9 during the measurement period

Weather data during the summer period

The average outdoor temperature during the measurement period was 12.3 °C. The highest temperature measured was 19.6 °C and the lowest 0.9 °C. The weather was typical considering the Finnish climate. There were a couple of colder early morning hours during the measurement period.

The relative humidity varied between 97 % and 27 %, the average being 67.6 %. The diversity of the results show the typical Finnish weather changes.

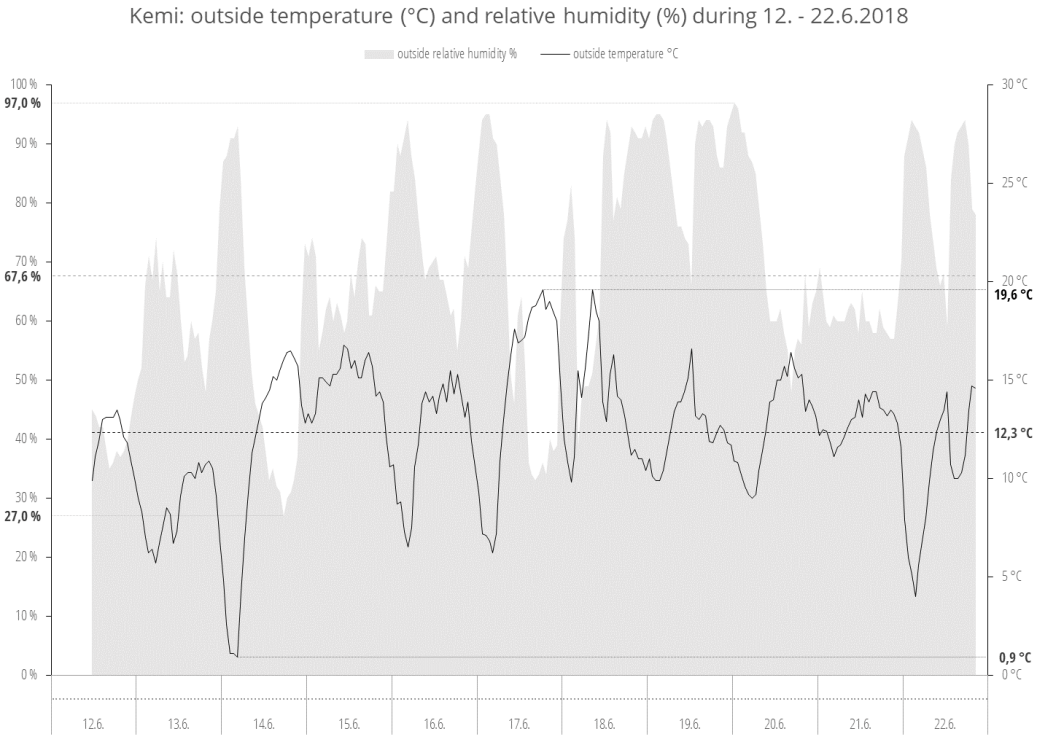

Figure 25 Outdoor temperature and relative humidity during the measurement period

User survey results

Part of the buildings staff answered to the user survey which gave useful user based information and experience of the buildings premises. The users were aware of the executed energy efficiency procedures in the building and the users were saving energy by their own actions.

Most of the administration buildings users had noticed unpleasant moldy smell throughout the building. Part of the users had also noticed visible mold, moist and darkened spots, surface damage and signs of water leakage.

Workers had also perceived staleness and lack of air conditioning. Draft and low room temperatures had been noticed often. Rarely high temperatures, cold surfaces and disturbing sounds were noticed.

The workers feel that they have good possibilities to affect the lighting settings and sounds. Some thought that they had good possibilities to affect the temperature but others did not. Most workers reported that it is not possible to affect the air conditioning.

Most workers felt the indoor air to be dry and the air conditioning is lacking. Some of the workers had physical symptoms like dry eyes, shortness of breath, asthma, loss of voice, drying of the mucous membranes and rash. The offices indoor air is said to worsen after the installation of the air-conditioning unit.

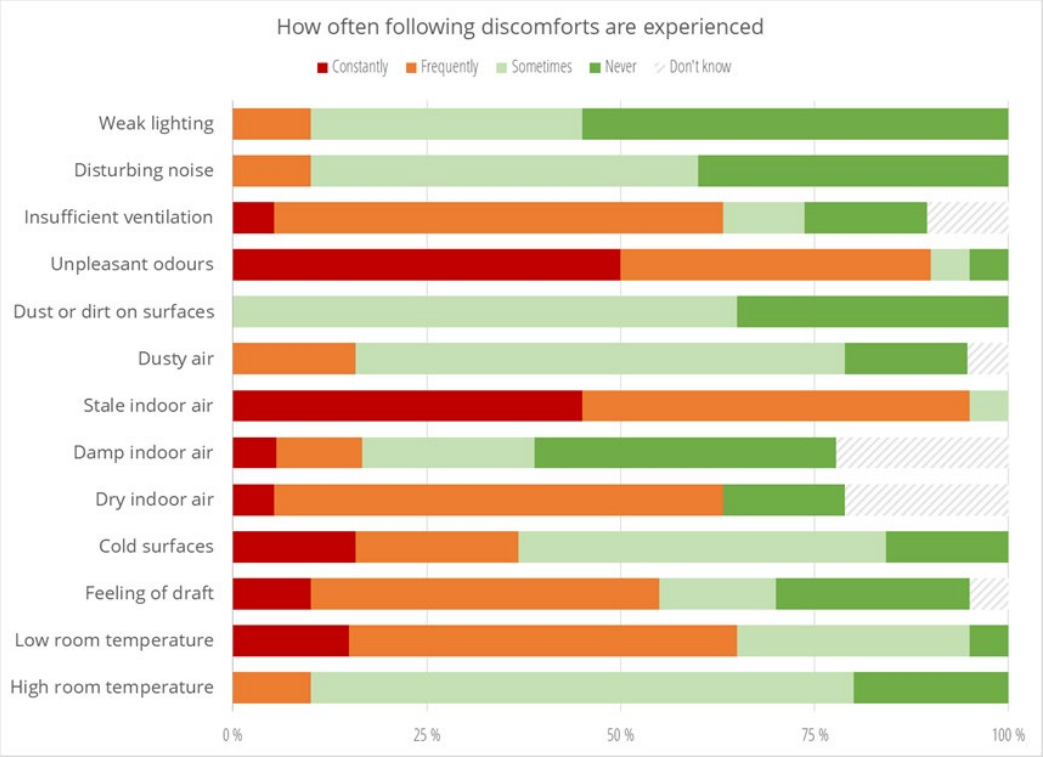

Figure 26 User survey results

Conclusions

During the summer, the temperature indoors remains in standard levels and the relative humidity is on comfortable and safe levels. The only obvious source of discomfort that is detected from the measure data is the extremely dry indoor air during the heating season. The collected data supports the user survey about the indoor air during the measurement period and the survey gives valuable information about the unmeasurable and subjective details. Users have reported of the problems related to the indoor air quality. The users have detected signs of moisture and water damage. The users have had health problems related to a poor indoor air quality. When all the collected data is taken into account it can be said that the pilot case is not a healthy building concerning the indoor air.¨

The indoor air health code does not contain precise guides concerning the relative humidity indoors. The code only defines that the humidity should not remain high enough that it causes a risk of microbe growth on surfaces, structures and equipment. Former guides and indicative publications say that the highest safe value of the indoor relative humidity has generally been 60 %. The guide does not define even loose guidelines for the lowest allowed values but it is known that too dry air has negative effects to the users. During the measurement period, high relative humidity values did not occur that could possibly cause risks of mold growth. During the heating season, the measured relative humidity was very dry and the users reported the same. This is a very common problem in Finland during winter and increasing the indoor humidity is a risk for mold growth.

The ministry of environment has defined the standards of indoor temperature. The indoor temperature must remain within 20–25 °C during the heating season and within 20–27 °C outside of the heating season. During the heating season the pilot buildings temperature remained mainly within the national standards in all of the measured rooms. In few rooms, the temperature dropped to almost 17 °C. Outside the heating season, the temperatures dropped under the national standard for a few brief moments, which caused minor discomfort or no discomfort at all.

Based on the measured data the quality of the indoor air is good. During summer period, the temperature and relative humidity remained within the standard levels. The temperature during the heating season remained close to the national standards but

dropped below it in few rooms. Relative humidity was low during the heating season, which is a typical problem in Finland. The user survey gave a different picture of the state of the indoor air. The users had reported signs of possible mold and moisture problems and some of the users had experienced health problems. These can be an enough of a reason for further actions.