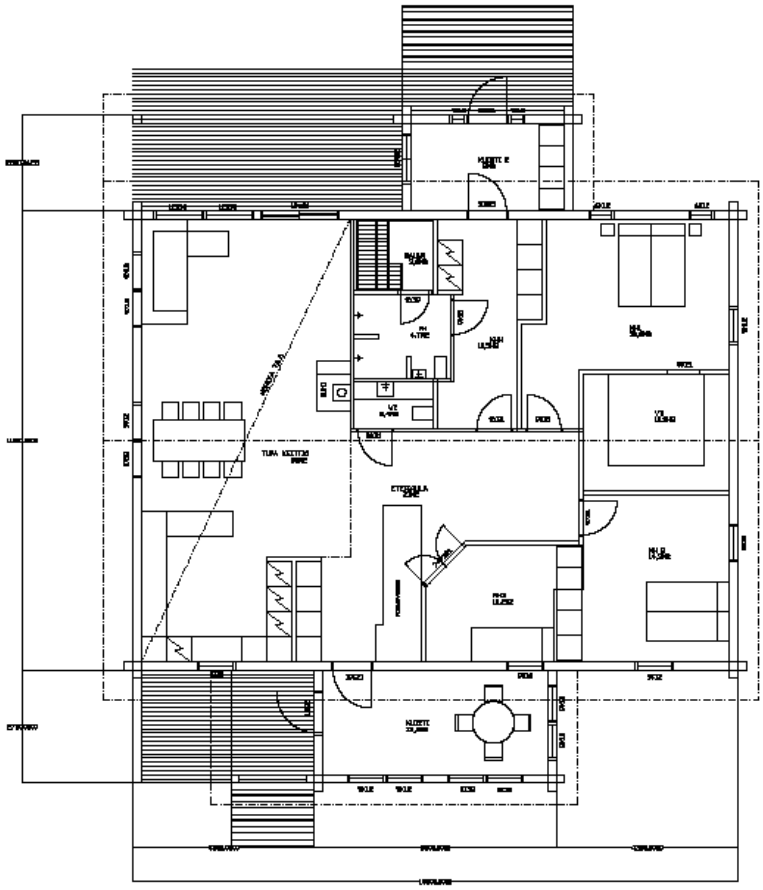
EEBAK Indoor climate survey



Pello log house

LAPLAND UAS

20.9.2018

Introduction

To verify and analyze the quality of indoor climate in our project's pilot cases, series of measurement were conducted in similar fashion in every country taking part in this project. Measurement data included indoor temperature and relative humidity monitoring for 4 weeks, split in two measurement periods: first in heating season, and second during summer.

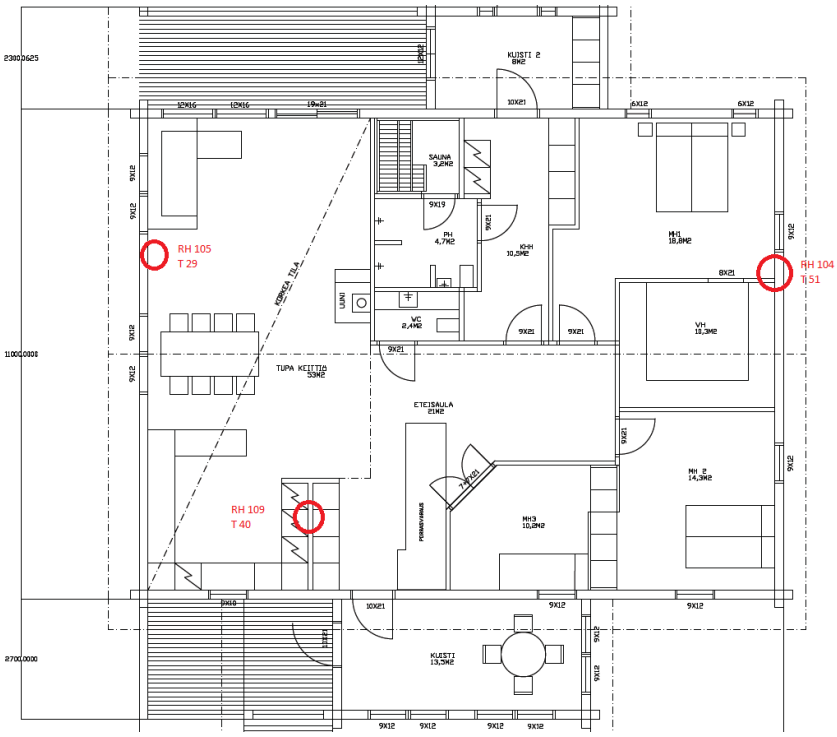
To analyze general user satisfaction and to detect possible defects and problems, a user survey was conducted in each pilot case. Users usually know the characteristics of a building best, since they are the ones spending most time in that particular building. It is also almost impossible to detect long-term variables and changes on a brief check to the pilothouse.

Pilothouse in Pello is residential single-family house located by the Tornio River, which separates Finland and Sweden from each other. The building itself is a log house made from laminated logs by Pellopuu and was built during 2012-2013.

First part of measurements were conducted with very compact iButton data logging system. During measurements in other pilot cases, the iButton sensors were quite prone to failing, which led to a purchase of a brand new measurement system for summertime indoor climate monitoring. System acquired was Lascar Electronics EL-USB-2+ RH / Temp data logger system.

Measurements in Pello pilothouse

Duration of all temperature and humidity measurement periods was at least 2 weeks. Measuring units were placed to the most crucial rooms of a building to analyze conditions in spaces that are mainly used, which in this case were living room, kitchen and bedroom. Every sensor was set to identical height, and situated strategically to minimize direct sunlight and other possible error sources.



Picture 1. Measurement points in the Pello pilothouse.

Measurement interval was set to the highest possible setting, limited by measurement instrument's memory capacity. On the first run on heating season, the interval was set to measure every 30 min. Heating season measuring period was conducted 12.3.2018 – 26.3.2018.

During the summer season, the new instruments made possible to record much more values on a single measurement so interval was more frequent, recording values once every five minutes. Summertime measurements were done 7.6.2018 – 27.6.2018.

Picture 2. iButton measurement system set up and running in living room

Building info

Building type: Single-family house

City: Pello

Purpose: Residential

Built: 2013

Surface area: 170 m^2

Volume: 481 m^3

Performed studies and measurements (Prior to EEBAK):

- Air leakage test
- Indoor condition monitoring
- Outdoor climate measurements

Heating, water & electricity:

-Heat production: Pellet boiler

-Heating energy demand: 46 MWh

-Electricity consumption: 8 MWh

User survey

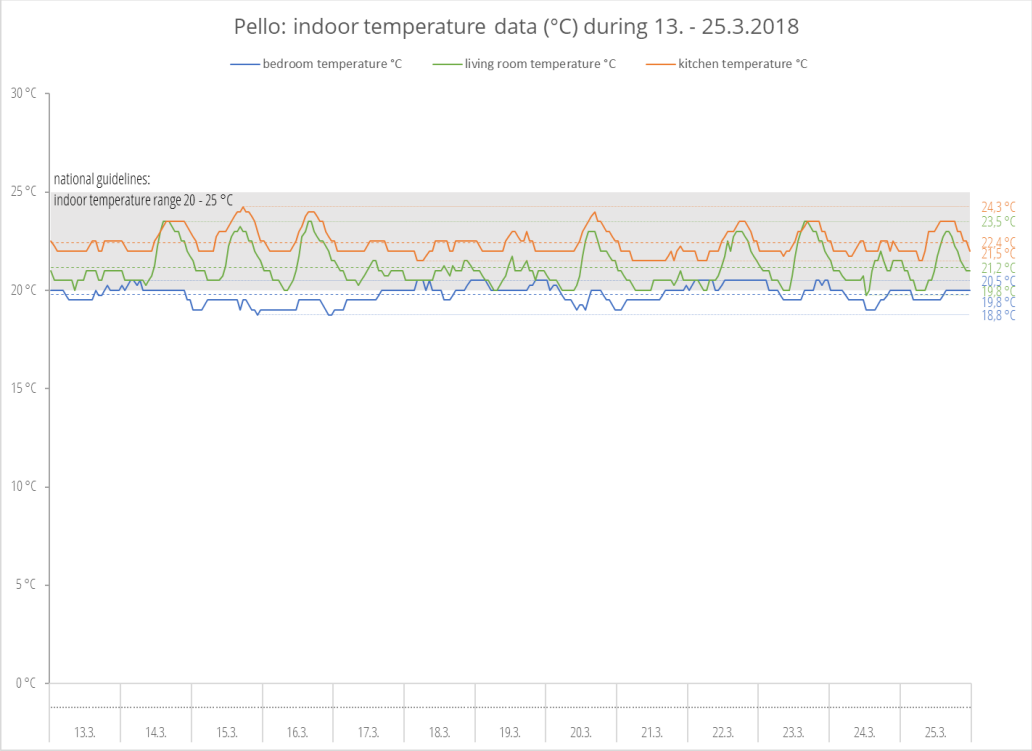
User surveys were used in this case to get more complete picture of indoor climate and user satisfaction. Even though we are able to measure many different parameters of indoor climate, it is also crucial to analyze how users experience the indoor climate. Users are usually the ones spending most amount of time in the building, so in theory they are most familiar with characteristics of building's indoor climate properties and other functions.

Uniform user survey was created so the results could be compared between different pilot cases. In this case, the questionnaire had to be translated to Finnish, but short, simple questions minimize the possibility of translational and linguistic errors and differences.

Scope of the questions is on the quality of indoor climate and energy efficiency. User is asked to describe his/her satisfaction regarding lighting, noise, thermal comfort, humidity and indoor air quality for example. Some simple yes or no-questions regarding mold growth are also included to detect obvious indoor air problems and possible health problems regarding them.

Results

Heating season results



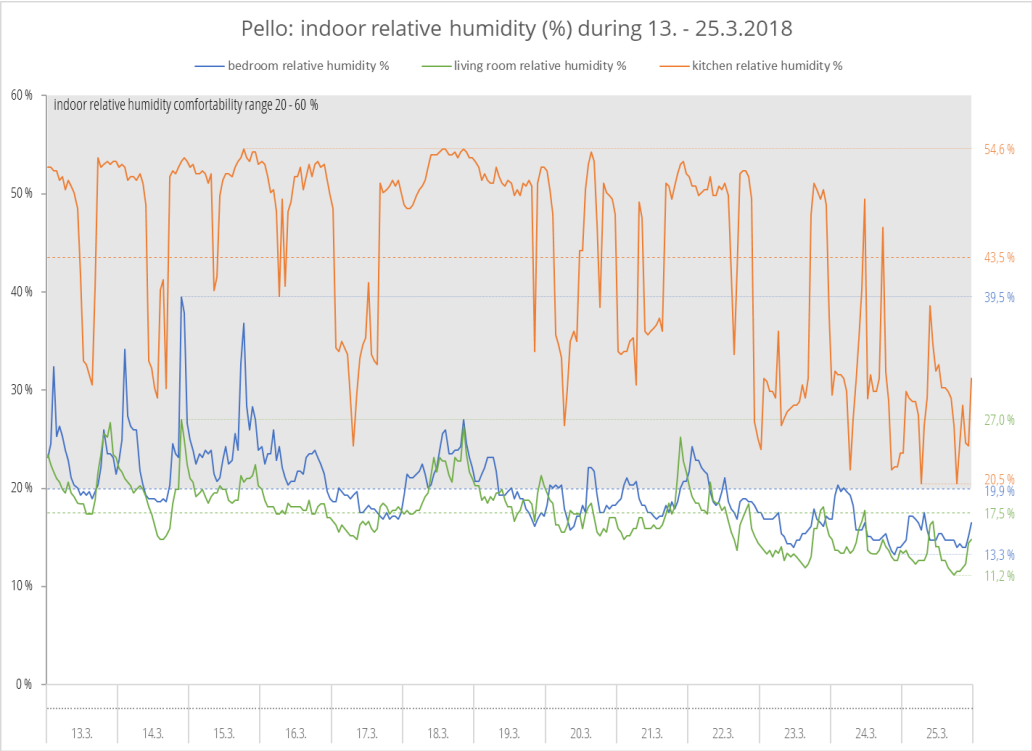


Figure 1 & 2. Temperature and relative humidity in Pello pilothouse during heating season.

Living Room

Average temperature of indoor air in living room was 21.1 C° during measurement period. There was no great deviations from average; minimum temperature being 19.5 C° and maximum 23.5 C°. Maximum temperature is surprisingly low considering the living room has very large, south- and west-facing windows that let ton of sunlight in to heat the building.

Average of relative humidity was 17.5 %. Humidity was quite low during whole measurement period, and during final quarter of that time hit very low minimum values of 11.1 % RH. Maximum value of relative humidity was also quite low 28.4 %.

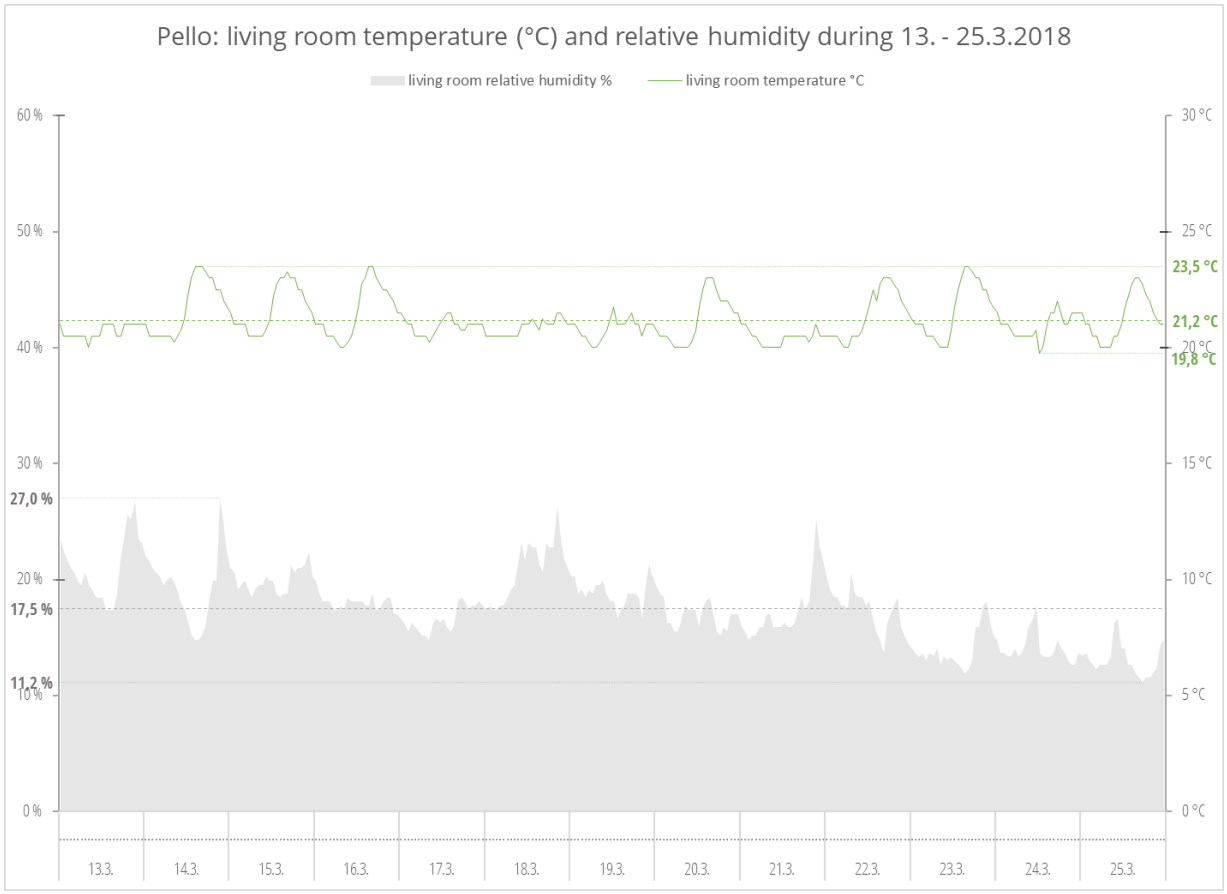


Figure 3. Temperature and relative humidity in living room during measurement period.

Kitchen

Average temperature of indoor air in kitchen was 22.4 C° during measurement period. Minimum temperature was 21.0 C° and maximum 24.5 C°. Highest temperatures are probably due to cooking. Besides high peak temperatures, indoor temperature is quite stable and on a comfortable level.

Average of relative humidity was 43.1 %. Humidity was noticeably higher than in other measurement positions but are explained by use of kitchen appliances and cooking. Moisture did not reach alarming numbers though, maximum being 54.6 % RH. Minimum value recorded was 19.0 % RH.

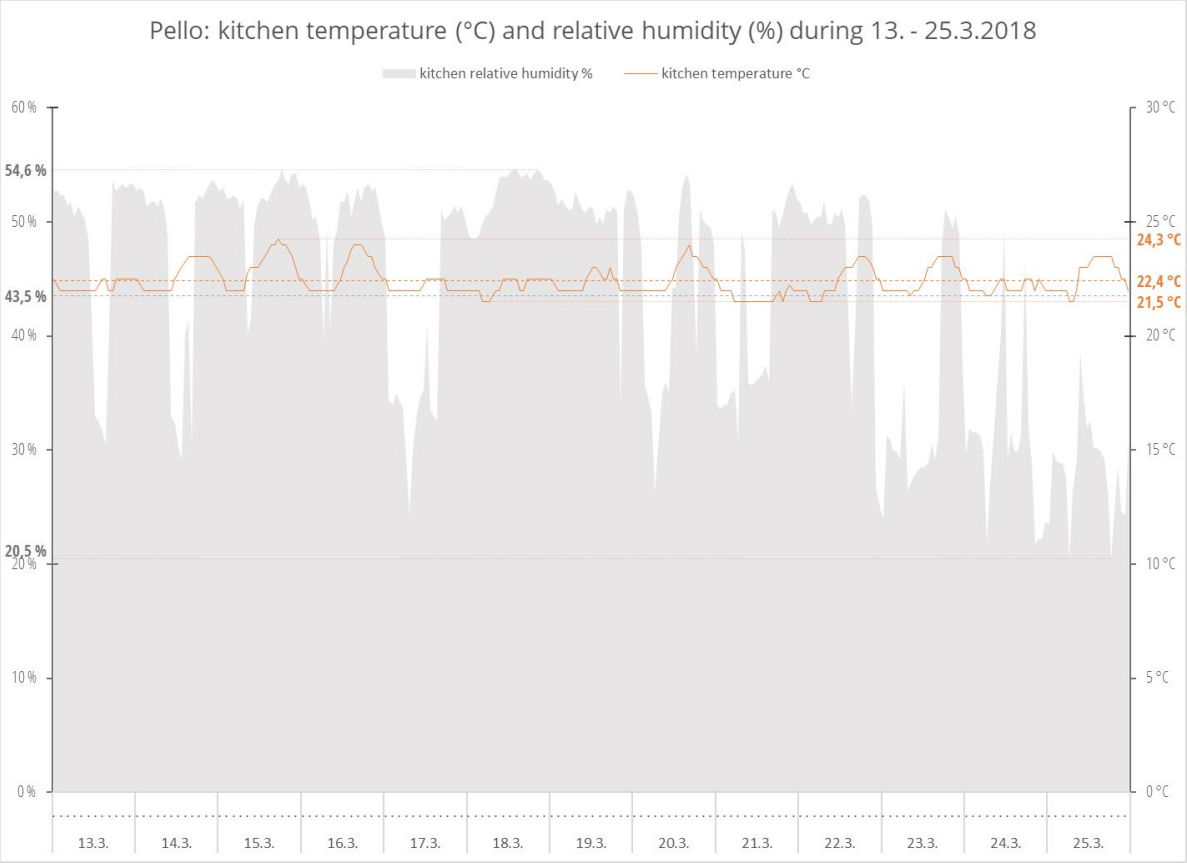


Figure 4. Temperature and relative humidity in kitchen during measurement period.

Bedroom

Average temperature of indoor air in living room was 19.8 C° during measurement period. There was no great deviations from average; minimum temperature being 18.5 C° and maximum 22.5 C°. Temperature is quite low at the times, below national standard, 20 C°.

Average of relative humidity was 19.9 %. Humidity was on a reasonable, safe level during entire measurement period. Like in the living room, during final quarter time humidity was very low. Minimum value were 12.6 % RH. Maximum value peaked briefly at 39.5, and is likely related to sauna and showering.

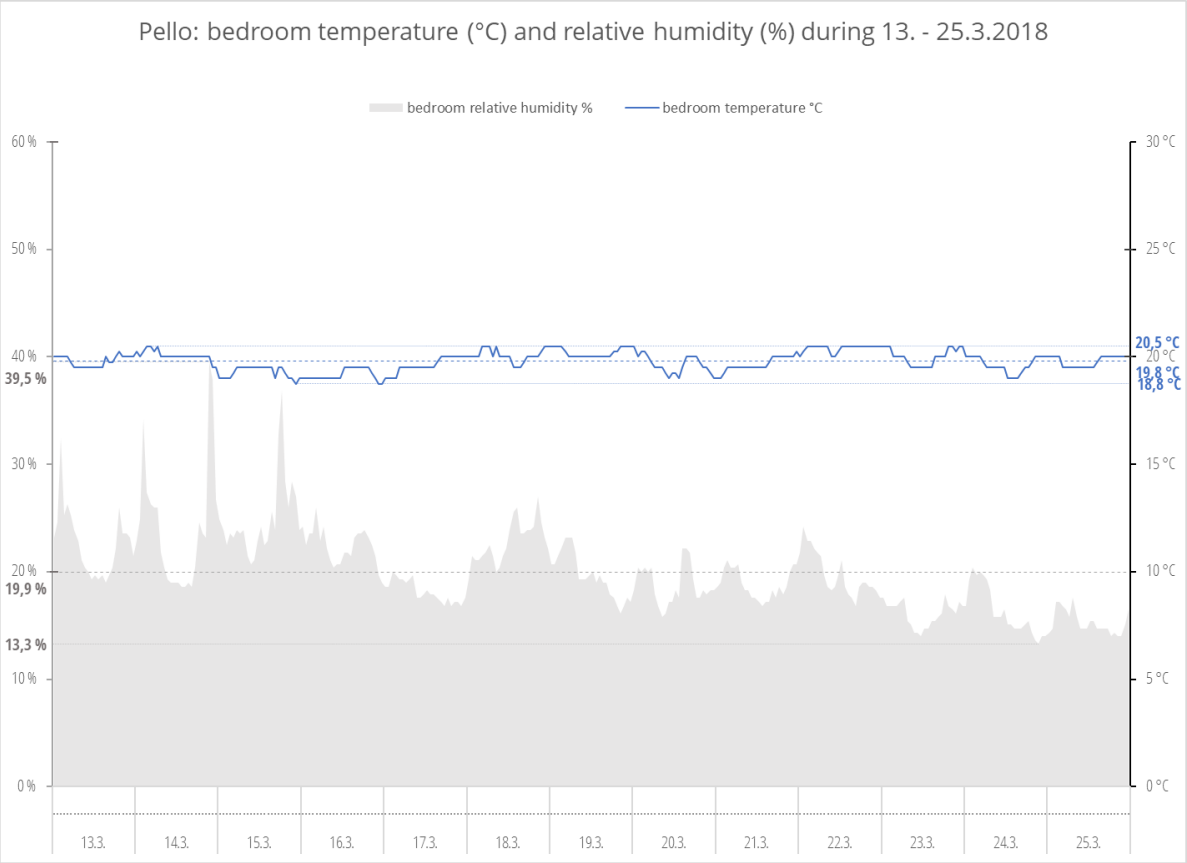


Figure 5. Temperature and relative humidity in bedroom during measurement period.

Weather data from winter measurement period

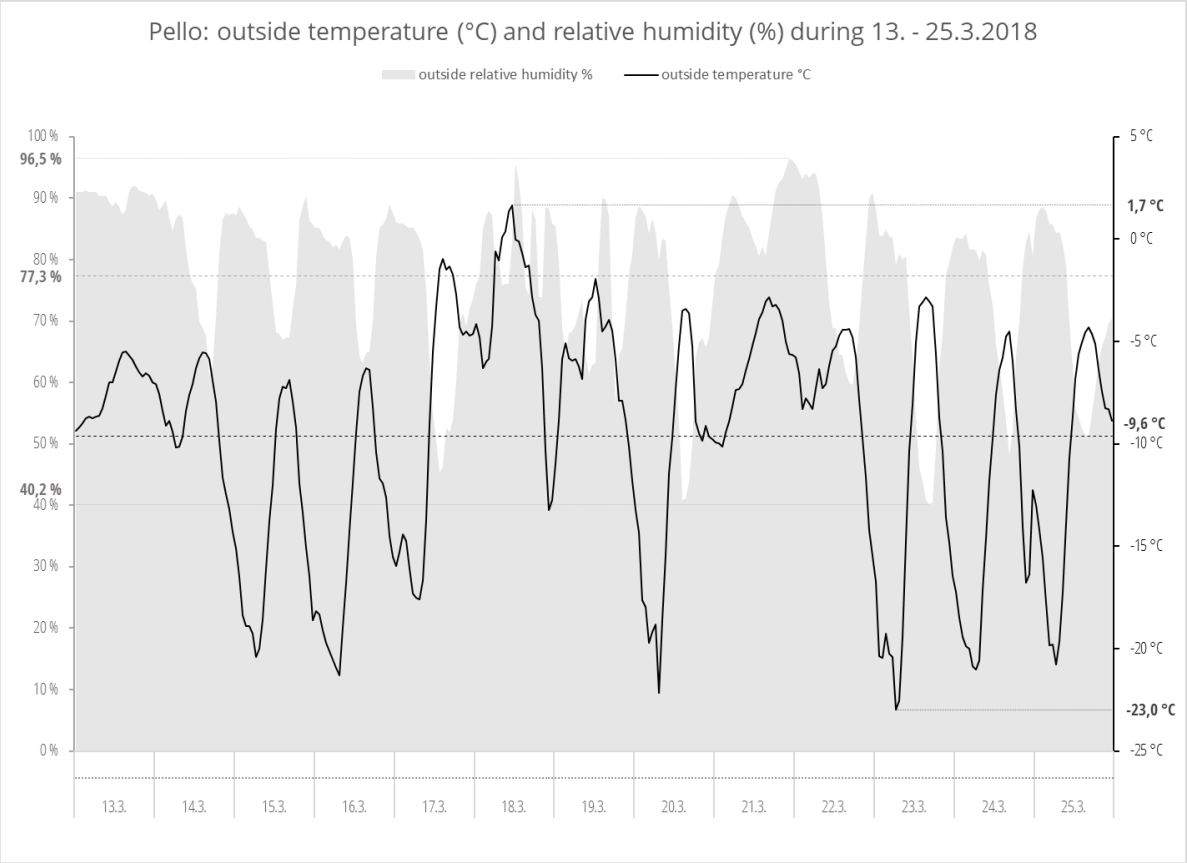
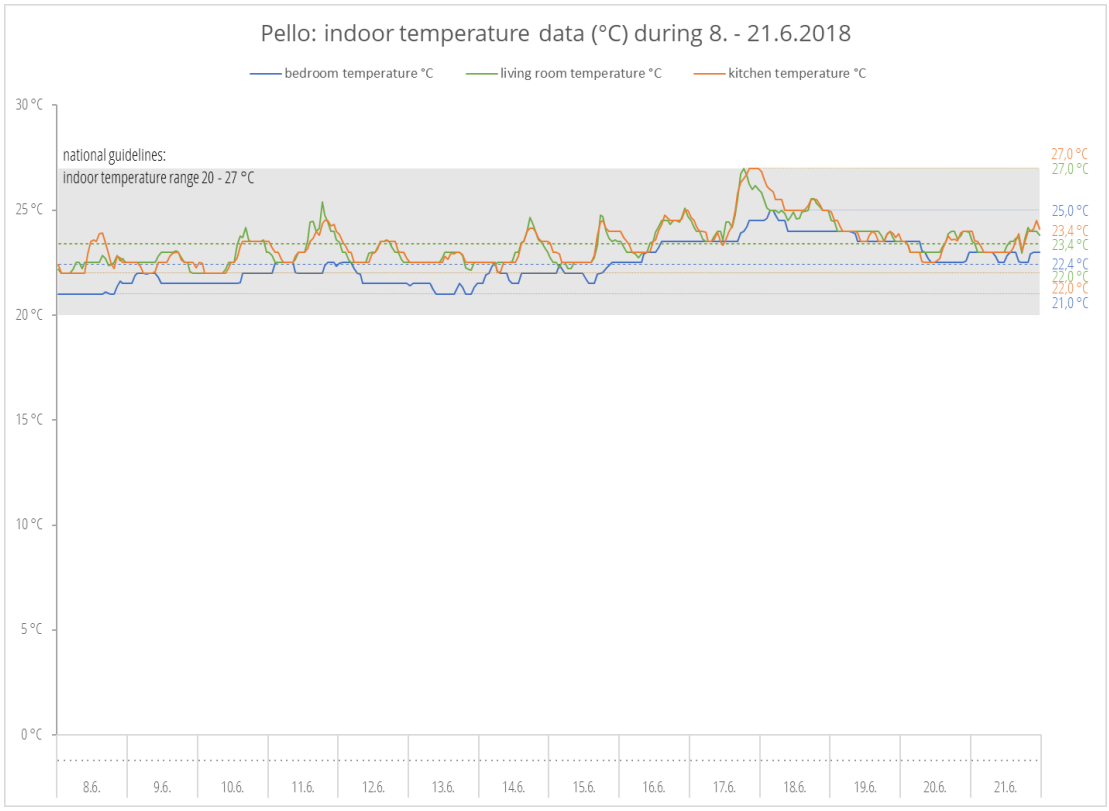


Figure 6. Temperature and relative humidity outdoors during measurement period.

Temperature outdoors during heating season goes through all typical temperatures of Finnish winter, temporarily above freezing point at warmest (3.1 °C) and – 23.1 °C at the coldest. Average temperature during this measurement period was – 9.7 °C. This shows clearly the difficulty of conditions in wintertime, temperature going above and below freezing point and temperature differences of 20 °C within hours' time.

Relative humidity was clearly inversely relative to the temperature, as expected. Averagae value of relative humidity was 77.3 % RH. Highest recorded value was 97.0 % RH, and lowest 39 % RH. All weather data was gathered from Finnish meteorological institute's database.

Summer season results



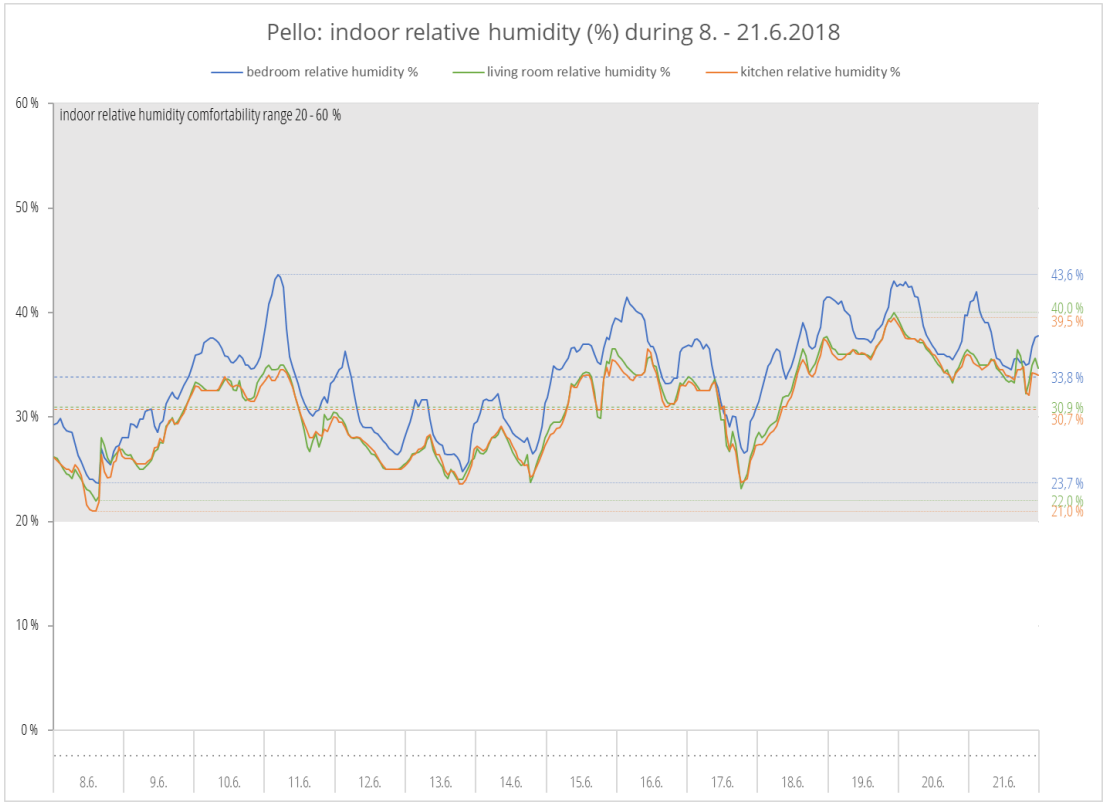


Figure 7 & 8. Temperature and relative humidity in Pello pilothouse outside heating season.

Living Room

Average temperature of indoor air in living room was 23.5 C° during measurement period. There was quite large deviations from average; minimum temperature being 19.0 C° and maximum 28.5 C°. Temperature did go briefly below national standard (20 C°). More regularly temperature did go above national standard's limit (27 C°), which is not surprising considering the living room has very large, south- and west-facing windows that let ton of sunlight in to heat the building.

Average of relative humidity was 31.8 %. Humidity was on a comfortable level during whole measurement period with very modest deviations. Relative humidity was on its lowest 21.5 %. Maximum value of relative humidity was 41.5 %.

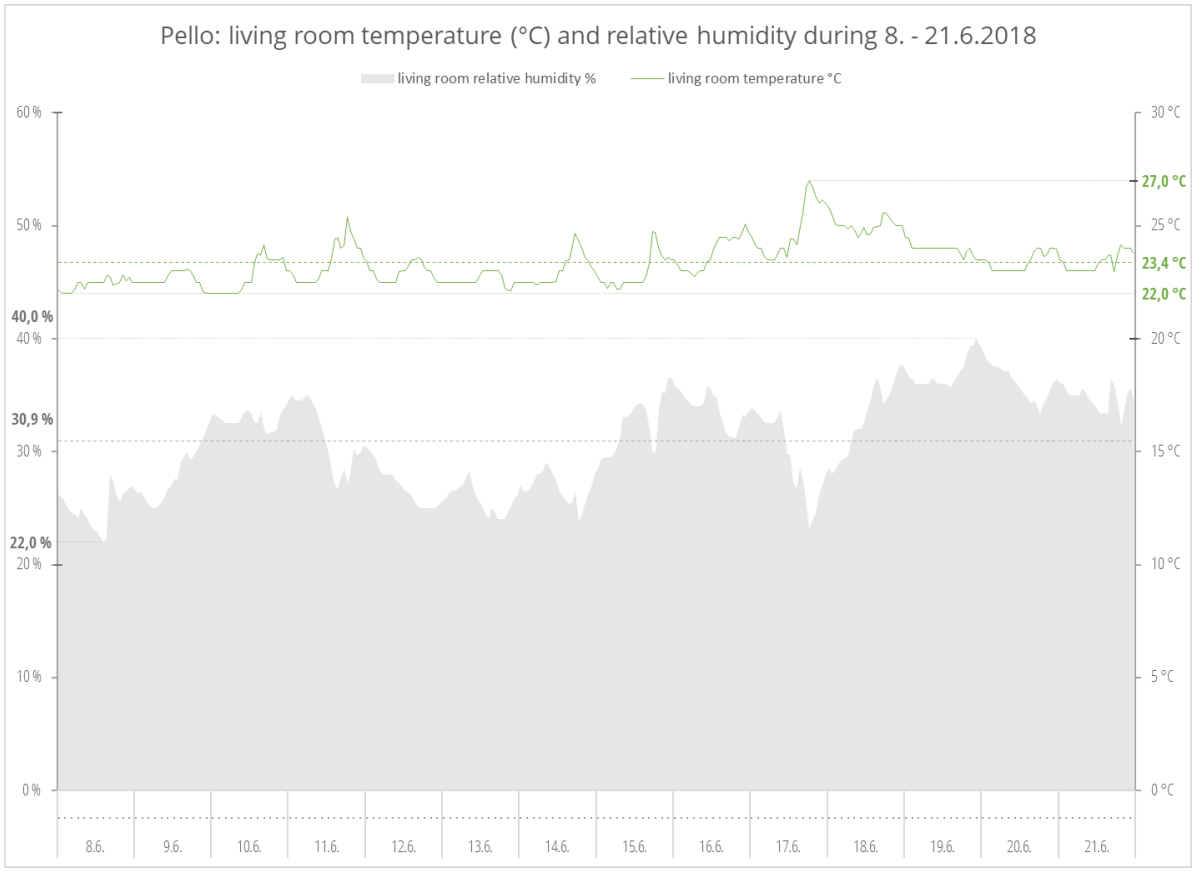


Figure 9. Temperature and relative humidity in living room during summer measurement period.

Kitchen

Average temperature of indoor air in kitchen was 23.6 C° during measurement period. Minimum temperature was 20.0 C° and maximum 27.5 C°. Highest temperatures are partly due to cooking, but kitchen is connected with living room, which has large windows facing south and west. High amounts of light coming through the windows heat up both the kitchen and living room quite a bit during daytime.

Average of relative humidity was 31.7 %. Humidity was almost identical with living room during whole measurement period since the two rooms are connected and have no large structures between each other. Relative humidity had minimum value of 21.0 % RH. Maximum value of relative humidity was 42.5 %.

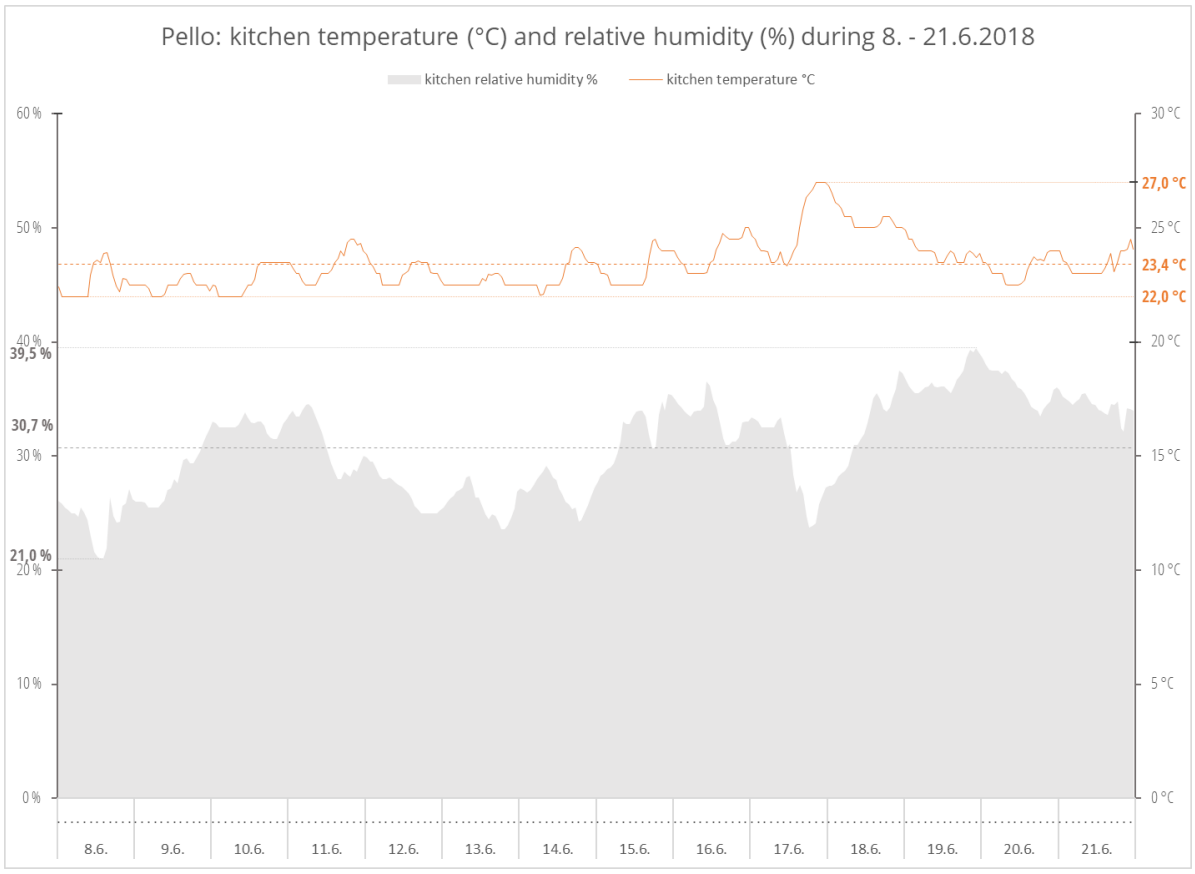


Figure 10. Temperature and relative humidity in kitchen during summer measurement period.

Bedroom

Average temperature of indoor air in living room was 22.5 C° during measurement period. Minimum temperature was 19.5 C° and maximum 25.0 C°. Maximum temperatures are a bit high but may be caused by large amount of heat coming through the living room windows, and still within national limits (20 – 27 C°)

Average of relative humidity was 34.7 %. Humidity stayed on a reasonable level for both people and building; minimum value was 23.5 % RH. Maximum value of relative humidity was healthy 44.5.

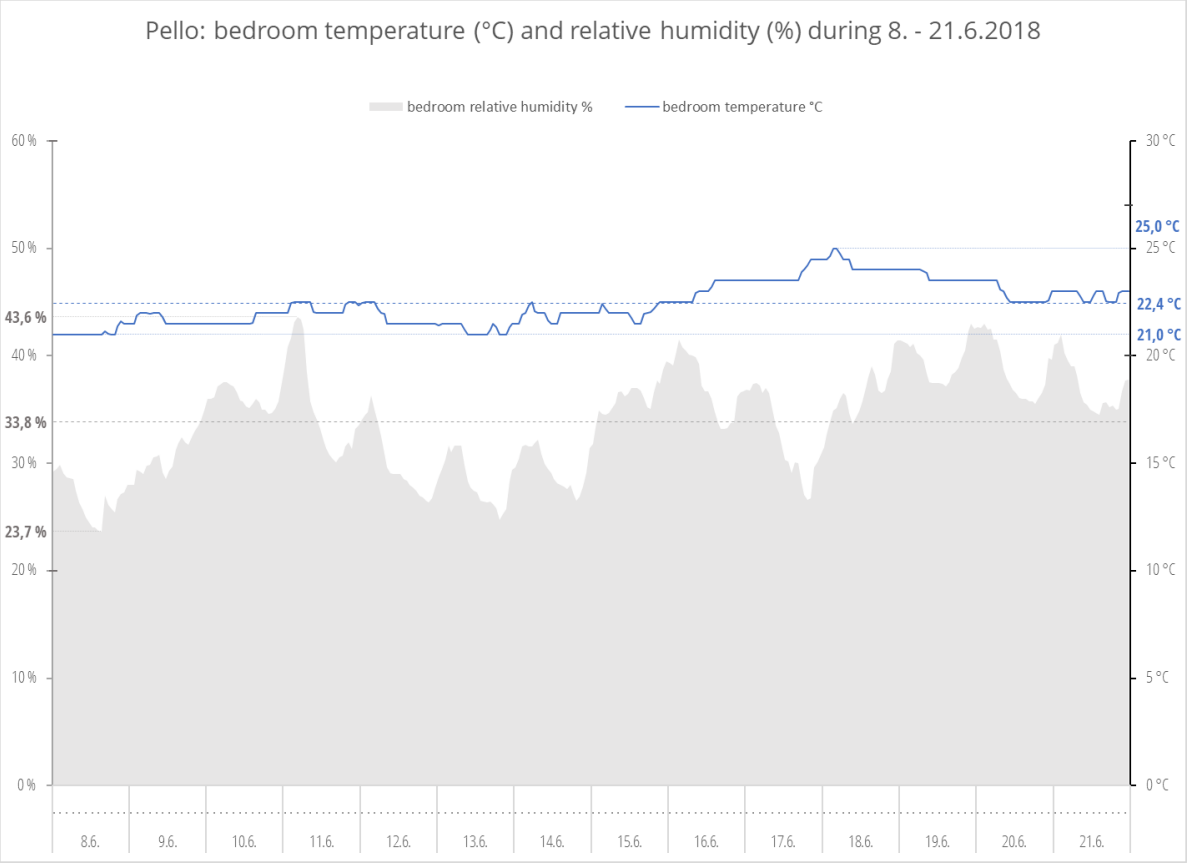


Figure 11. Temperature and relative humidity in bedroom during summer measurement period.

Weather data from summer measurement period

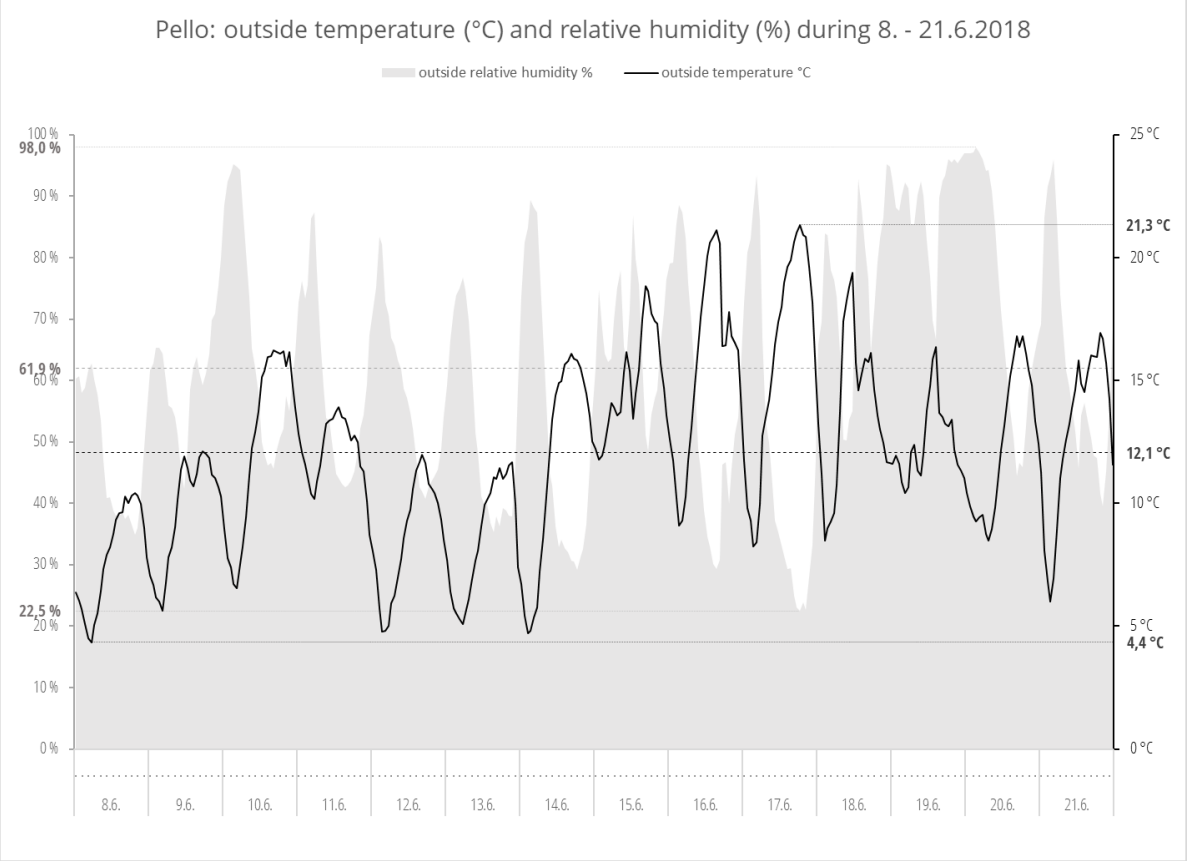


Figure 12. Temperature and relative humidity outdoors during measurement period.

Weather during summer measurement period represents typical weather during June in Finland. Average temperature outdoors during measurement period was 12.5 °C. Lowest temperature recorded was 4.3 °C. Highest temperature was 22.2 °C. No extremely high temperatures occurred during measurement period.

Relative humidity follows temperature inversely, and changes in humidity are large. Average relative humidity was 62.2 % RH. At lowest, relative humidity outdoor was 21.0 % and topped at 98.0 % RH. Values are almost identical to the ones measured near Wellevi pilothouse, Kittilä.

User survey results

One of the building owners filled the survey, representing opinions and experiences of whole 4-person family, which is typical response when working with single-family house. Family has been living in the house since it was built, from 2013. Since building is quite new, no renovations or fixes have been done yet. There are no active energy saving actions or measures being implemented during use of the building.

Users are mostly satisfied with building's thermal comfort. Slight coldness is reported, but otherwise temperature is felt to be just right. Differences between measured and felt thermal properties stepped into great role in this case, surprising analysts. Large living room windows in the log house let great amounts of daylight in and heat the house excessively, but users did not report experiencing indoor air temperature too hot.

Indoor air was experienced a bit stale and damp at times. Owner did report feeling the volume of ventilation to be too low for his liking. That would seem like an obvious reason for defects in indoor air mentioned above. Indoor air was not experienced too dry. Most frequently encountered deficiency indoors was weak lighting. Users have not spotted any typical sings of mold growth or any other indoor health problems, and do not suffer from any medical conditions that could be related to poor indoor air health.

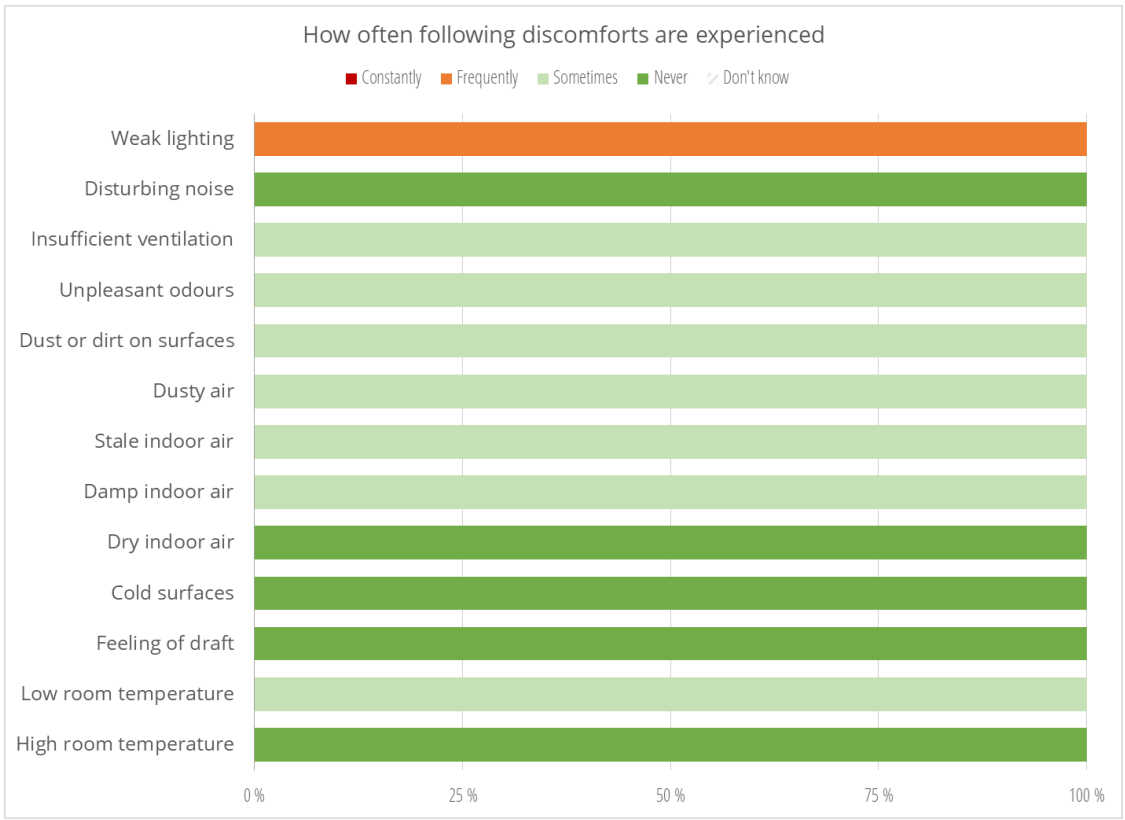


Chart 1. Results displaying how often discomforts are experienced in pilothouse.

Conclusion

By looking at the data collected during measurement periods, the indoor climate is generally on acceptable level. For the most parts, temperature is reasonable and humidity is on a comfortable and safe level. Only possible discomforts spotted from measurement data are dry indoor air during heating season, and excess heating of living room during sunny summer days. Temporarily temperature dips below national standard, but only briefly.

It has been noted in past studies, that measured and experienced indoor climates may differ from one another quite a bit, which is one of the reasons for the use of user questionnaire. Even though measurement data told us a story of generally good indoor climate with moments of dry indoor air and uncomfortably hot indoor air, the users did not report experiencing any problems with either of those. Results with temperature and relative humidity were almost opposite of expected, and users reported the indoor air to be cold and damp seldom. Data backs up the occasional feeling of cold, but dampness is not noticeable in measurement periods' data. Users did not report any problems with indoor health. No signs of excess moisture or water damages were noted, and measured data backs up the findings of user survey. Users did not have any space-related health issues. Considering all data collected, it is safe to say that this pilothouse is healthy house when it comes to mold and other impurities.

Indoor health code does not define exact guidelines for relative humidity indoors. Code specifies only that humidity of indoor air must not stay longer periods on so high level that it could cause risk of microbe growth on surfaces, structures or devices. In former guides and suggestive publications, the highest safe value for relative humidity indoors has usually been 60 %. Code does not determine even loose guidelines for lowest allowable value, even though the fact that too dry indoor air may have negative effects on building users is widely known. No risk of mold growth due to too high relative humidity was present during measurement periods. During heating season, the relative humidity was very dry at the times, but users did not report experiencing it dry.

Ministry of the Environment has decreed standards for indoor air temperature. Indoor air temperature must stay within 20 – 25 C^o during heating season and 20 – 27 C^o outside heating season. During heating season, temperature in pilothouse stayed mainly within those boundaries in living room and kitchen. In bedroom, temperature did dip below 20 C^o regularly. Outside the heating season, temperatures went below national limit only very briefly, causing little to no notable discomfort. On the high side of temperatures, limits were crossed more often in the living room due to large south- and west-faced windows. Problem could be easily solved with some shading.

Overall, the indoor climate is good, main problem being excess heating during sunny summer days. Other, smaller discomforts like lighting are easily solvable, since the owners have full control over the property. Low energy consumption does not have negative affect on comfort of users.